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THE BIOLOGICAL STATIONS OF EUROPE

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ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

Department of the Interior,
Bureau of Education,
Washington, July 30, 1910.

Sir: Scientific research, which widens the bounds of knowledge, is as essential a part of the higher education as is instruction, which looks to the transmission of knowledge and training in its use. To promote a better organization of the agencies of pure research in this country, and especially those agencies connected with the graduate schools of our universities, is therefore one of the ends to be sought in the work of this Bureau.

I have been impressed with the wide extension of laboratory methods in the field of biological study, and with the varied usefulness of the research stations through which such extension has been effected. While seaside laboratories have been in operation for a generation and more, their growth in number and in the range of their service has been noteworthy. Accordingly, I gladly availed myself of the opportunity presented by Prof. Charles A. Kofoid's stay in Europe during the year 1908–9, to secure from him an account, based on his own observations, of the organization and conduct of such stations in the several European countries. His report, prepared at my request, is respectfully presented herewith for publication in the Bulletin of this Office.

This monograph is intended to serve a practical purpose, that of furnishing such an account of the European stations as will further the advancement of similar stations in America. It will undoubtedly be of interest moreover to all who are concerned with the biological sciences and are following the course of their development.

Very respectfully,

Elmer Ellsworth Brown,
Commissioner.

The Secretary of the Interior.

PREFACE.

This report is based in large part upon a personal examination of the fresh water and marine biological stations of Europe, made in the summers of 1908 and 1909. Its purpose is to put in convenient form for reference an account of the history, organization, equipment, and work of the various stations of Europe, and to indicate their relations to research and to education of advanced and elementary or popular characters. Special attention has been given to the economic or applied scientific phases of their activities in the firm belief that biological stations and their methods of attack upon biological problems are destined not only to add greatly, and, in a unique way, to the advance of knowledge but are also of prime economic importance. They are laying the foundations for a scientific aquiculture that will make possible the conservation of the æsthetic and economic resources of lakes and streams from threatened pollution and destruction, and that will facilitate the full reaping eventually of the annual harvest of the sea without the destruction of its sources. In their field, biological stations may do in our country for aquiculture what experiment stations have done, and are doing, for agriculture.

The writer is under many obligations to the directors and members of the staffs of the stations herein described for countless courtesies in securing the data for this report.

BERKELEY, CAL., *December 24, 1909.*

THE BIOLOGICAL STATIONS OF EUROPE.

CHAPTER I.

THE FUNCTIONS OF BIOLOGICAL STATIONS.

A decade after the publication of "The Origin of Species" the fructifying influence of the new idea had not only brought new zest to classroom instruction and made the biological laboratory an inseparable part of the equipment of a university, but it also sent the investigator forth from the museum and laboratory to that greatest of the arenas of organic evolution, the seashore. Imbued with the idea that the great problems in biology which the theory of natural selection had brought to light could be solved more speedily and more satisfactorily at the seashore than elsewhere, a young enthusiast, fresh from the laboratories of Jena, set out to establish and equip a great marine observatory on the shores of the Mediterranean. Others had preceded young Dohrn, but none so clearly acknowledged his debt to Darwin. A host followed him, not only to Naples, but to scores of stations springing up in quick succession in other lands and on far-distant shores.

The causal analysis of biological phenomena by the aid of the experimental method is giving new impetus to the utilization of biological stations and, even more than Darwin's great idea, is the mainspring in the maintenance of old and the establishment of new stations, and is leading to a broader and more comprehensive foundation for the work of the nearly one hundred institutions in Europe which may be classed as biological stations.

The past decade has witnessed a great increase in the operation of the economic and industrial motives for the establishment of biological stations. This shows itself in the increasing use of their facilities in medical instruction and research along physiological lines and especially in the modern development of fisheries research. Prior to the present century much of the fisheries research was remote from practical significance, more of it was desultory and discontinuous, and all of it was utterly inadequate to establish a scientific basis for the conduct of the fisheries and fish culture, which even now rest primarily upon an empirical basis. The utilization of machinery in

fishing operations, the great improvements in transportation and marketing, and the increasing demand for the products of the sea for food have made imperative a scientific basis for aquiculture if the harvests of the sea are to be fully reaped and its resources to be maintained unimpaired for the future. The pollution of the lakes and streams by municipal, industrial, and chemical wastes, and the ill effects of overfishing threaten to exterminate the native fishes and to destroy entirely a source of great pleasure and profit to the human race. To meet these exigencies created by the rapid advance in our civilization a new type of station is now in the process of evolution, one, moreover, which is no longer merely a biological station, but rather a station equipped for the solution of biological problems with the aid of all pertinent sciences. The causal analysis of the problems surrounding a living organism in its environment calls for exact and thorough knowledge of both the animal and its environing factors, and necessitates the aid of chemical, physical, hydrographical, and meteorological research in close correlation with the biological and subordinate to it. The biological station of the future is thus coming to be a marine or fresh-water observatory with a broader basis and wider scope of action.

This wider outlook has dominated the work of the International Commission for the Investigation of the Sea, which began its operations in 1902 and has at present the cooperation of eleven countries—England, Scotland, Ireland, Norway, Sweden, Finland, Russia, Denmark, Germany, Holland, and Belgium. While its biological work is mainly restricted to the practical problems of the fisheries and is thus stimulated by the economic motive, the method of its prosecution is the broader one above outlined. This, the first example of international and scientific cooperation which the present century has witnessed, is full of profound significance for the future work of biological stations upon problems less directly economic in their nature.

The isolation and differentiation of fresh-water environments have thus far prevented like cooperation in the newer fresh-water fisheries research stations that have been springing up in Europe in the present decade. The example of the Munich fisheries experiment station under the able direction of Professor Hofer has been potent in stimulating the opening of like enterprises in Austria, Hungary, Prussia, Sweden, and France, and in creating a demand for such institutions elsewhere. These newer experiment stations are very much like our own agricultural experiment stations in that they are mainly research establishments devoted to the analysis and solution of practical problems of aquiculture and pisciculture. They are subsidized by the state and often have advisory or even police functions, are usually connected with universities or technical schools,

and are always manned by men of scientific training. The large work they are doing in restoring and improving the sanitary conditions and food resources of the streams and lakes of Europe is an abundant justification for their existence. There is a great field in our own country for the development of local stations with state and federal support directed toward the practical problems of the fisheries. Obviously such stations might well have the same relations to the scientific faculties of our state universities and to the central coordinating bureau at Washington that our agricultural experiment stations now bear.

The great research stations of Europe are supported largely, and often almost exclusively (except in Great Britain), by state and local funds. This is made possible in European countries by the recognition on the part of the state of the relation of research to higher education in biological sciences and by the centralized forms of administration of educational policies and funds. At some time, possibly not far distant, it may be found advisable that our own Federal Government should assume through some central agency the adequate support of two great research stations, one on the Atlantic and one on the Pacific, as an integral part of our system of higher education. It is obvious that such stations should be free from the domination of economic interests, though it might be to the great advantage of both if the fisheries interests and the research stations should stand in an advisory and cooperative relation to one another.

The functions of such great research stations are quite distinct from those of smaller, local fish-cultural experiment stations, which may well take over all formal instruction, as well as the investigation of local and especially of economic problems.

The functions assumed by a biological station determine largely the character of the location best suited to its work. The factors to be considered in the location of a marine station are accessibility, nearness to sea, abundance and variety of local fauna and flora, ease of access to varied types of environment, purity and salinity of the water, tidal amplitude, and climatic conditions.

These different factors operate with varying force according to the relative stress laid upon the several lines of work which may be presented at a station. A great international or national station, for example, should be on or near main lines of travel, preferably near a city where the problem of living quarters may be solved independently of the station. It should also be located with especial reference to the variety and richness of the fauna and flora and the purity of the water for experimental work. Stations serving local interests and concerned largely in instruction, on the other hand, are usually located with reference to ease and quickness of access to their

clientele, and often provide living quarters in connection with the station building. The research station, as a rule, finds a better location on warmer shores, since southern faunas and floras are more varied than northern. Variety of fauna, on the other hand, is not so essential for the station whose function is teaching and whose interests are local. The station whose aim is economic is obviously best located in or near great fishing centers where contact with fisheries problems is most intimate.

Purity of the water supply, as shown in its freedom from admixture with fresh water and from contamination by sewage, industrial wastes, or considerable quantities of shore detritus due to tidal currents, is a matter of great importance to all stations where experimental work or fish culture is carried on, or where varied types, especially pelagic forms, are kept in aquaria. Much may be done by sedimentation and by preliminary storage in the dark to improve polluted waters for circulation in aquaria and laboratories; but, after all is said, purity of water supply is the greatest asset of the marine station.

The distribution of water to aquaria and laboratories is best made in piping of lead, glass, hard rubber, or well-enameled iron, with hard-rubber fittings. Iron, hard lead, copper, and brass should be avoided in reservoirs, pipes, and pump. Cast-iron pumps and sea pipes properly asphalted, if flushed before using, have proved unobjectionable. Hard-rubber pumps have generally been discarded because of breakage and expense. The use of compressed air in pumping is to be highly recommended, as it makes possible the elimination of the metal and fittings of the ordinary pump and delivers aerated and cooled water to any desired level.

The utility of an aquarium to the biological station is great. The indirect service, which the opportunity of observing the living animals renders to naturalists working at the station, and ample provision of material which the routine maintenance of aquaria invariably provides, more than compensate for the expense of upkeep in properly installed, equipped, and constructed aquaria. The cost of pumping, attendance, and feeding is considerable, and few, if any, exhibition aquaria, even the more favorably located ones, yield, however, an income sufficient to meet the expense of maintenance.

The two principal functions which biological stations fulfill and which can not be equally well fulfilled by any other existing educational agency are those of instruction—elementary, technical, and advanced—and research in the field of pure science and its applications. To this may be added the esthetic element contributed to all who visit it, by a well-managed aquarium.

A well-equipped and scientifically maintained aquarium in connection with a biological station reveals a new world of life of never-

failing interest and pleasure to many people, young and old alike, who are neither students nor investigators in the biological field. In respect to novelty and interest, biological stations are comparable with our great astronomical observatories. In spite of what has been attained in the way of biological instruction, there still remains a large field of popular instruction and stimulation of interest in biological science which no institution can so thoroughly and effectively accomplish as a scientifically directed marine aquarium, which should form an integral part of every marine station easily accessible to the public.

The technical and popular instruction of the nature of university extension work among fishing and seafaring folk along biological and piscicultural lines is exemplified in the fisheries station at Piel-in-Barrow, in Lancashire, and at Grenoble and Toulouse. These "fishermen's institutes" are mutually beneficial and lead to a better understanding on the part of investigators of fisheries problems and on the part of fishermen to a juster appreciation of the efforts of the state to improve and regulate the fisheries. The development of a scientific aquiculture must utilize much of this work in order to put into operation by popular education the results of investigation. The biological station may be made a potent agency in this extension work, as well as in the instruction in the technique of fish culture.

There are few, if any, of our universities and colleges which are located on the seashore or directly upon the shores of lakes or streams. The richness and variety of marine life as contrasted with that of fresh water, and the difficulty of studying either, except in the most meager fashion and at much expense, place the marine biological station in a position of unique advantage over all educational agencies in the biological field, while both fresh-water and marine stations bring the student to living animals in their normal environment, and thus make possible the highest type of instruction and research. The utilization of the marine station in the Easter and summer vacations for the formal instruction of university classes is universal in France, Austria, Sweden, and Norway, where universities are directly in control of their own stations, while English students gather at Plymouth for class instruction, and German students swarm to the Mediterranean stations in the April recess for individual work and research.

Stations engaged in instruction of the formal type need large general laboratories, small reference libraries, aquaria for study and observation, and should be located where the fauna is abundant and easily obtained. Varied fauna and great purity of water are not prime requisites.

The research function of a station is its highest one, and at the same time exhibits its greatest scientific and economic value. It is also

the most expensive one to equip and maintain and the one which gives it least publicity. The biological station is a unique agency in biological research, indispensable in the equipment of a nation for the upbuilding of leaders in biological teaching and in the development and expansion of the spirit of research. It fulfills this function by placing the investigator in the place of greatest advantage with respect to the living material which he seeks to control and providing the opportunity for long-continued and close observation and experiment upon abundant and varied material. Not the least valuable factor is the stimulus of contact with other investigators engaged in other lines of research. This factor alone places a limit upon the number of separate research stations which can be maintained to advantage. The larger the station, the more international its clientele, the greater its value to the investigator in this respect.

The station equipped for research needs many small laboratories for individual investigators, affording quiet and freedom, a great library of original sources, a large (and for the future much more than in the past) equipment of aquaria for observation and experiment, great purity of water, and great care in installation of circulating and aerating systems, an ample field equipment, the services of collectors trained by years of experience with the local conditions and fauna, easy and quick access to a varied fauna, and, at least, a small permanent scientific staff in charge. Climatic, social, and æsthetic conditions also profoundly affect the productive capacity of a station, while the personalities of the director and permanent staff do much to create esprit de corps and an atmosphere conducive to vigorous and effective research.

CHAPTER II.

ITALY.

INTRODUCTION.

In proportion to area Italy has a great extent of coast line, and one, moreover, bathed by warm seas rich in varied marine life, offering many choice locations for marine stations. That they have not multiplied here as in France is doubtless in part due to the pre-eminent excellence of the great station at Naples (1872) whose ample facilities provide opportunities for a large number of investigators, and in which Italy has always had a large representation. This station draws its support from many nations and justly deserves the appellation of international, though located in an Italian city.

Local needs have led to the opening of a small station on the beautiful Italian Riviera at Rapallo (1889) by the University of Turin, and by Kleinenberg and others in connection with the university located at the famous Straits of Messina where Dohrn and Mikluho-Maclay in 1867 opened a temporary station. The new station at Cagliari (1909) in Sardinia with its modern equipment and unique location is Italy's latest achievement.

Modern developments in fish culture have led to the establishment of a hydrobiological institute at Milan (1907), which utilizes the fine aquarium building of the Milan exposition for its laboratories. Zeal in geographical exploration has led a group of Roman scientists to found the limnological station at Bolsena, the biological features of which are as yet undeveloped. A strong movement has been instituted also in Rome to establish upon the shores of the Mediterranean an international survey of its waters along lines so successfully followed in the North Sea and adjacent waters by the International Commission for the Investigation of the Sea, with headquarters at Copenhagen.

NAPLES ZOOLOGICAL STATION.

[Address for letters and requests: "Verwaltung der Zoologischen Station, Stazione Zoologica Napoli."]

Director, Prof. Dr. Reinhard Dohrn.

Assistant emeritus, Prof. Dr. Hugo Eisig.

Assistant in charge of zoological department and Zoologischer Jahresberichte, Prof. Dr. Paul Mayer.

Assistant in charge of "Fauna und Flora," "Mittheilungen," and artists, Prof. Dr. Wilhelm Giesbrecht.

Librarian and expert in photography, Dr. Emil Schöbel.
Conservator, Dr. Salvatore Lo Bianco. (Deceased April 10, 1910.)
Assistant in charge of museum, Dr. Reinhard Gast.
Assistant in charge of physiological department, Dr. Richard Burian.
Assistant in charge of chemical department, Dr. Martin Henze.
Zootomist for physiological department, Dr. Victor Bauer.
Assistant in zoological department, Dr. J. Gross.
Secretary, Mr. Hermann Linden.
Engineer and architect, Mr. E. Gravina.
Telegraph address, Acquario, Napoli.

The staff of employees includes three artists, four préparateurs, one precision mechanician, ten laboratory servants, three engineers and firemen, two pump men, one smith, one mason and plumber, one carpenter, one keeper of the aquarium, one night watchman, two cashiers, two porters and commissionnaires, and nine fishermen permanently employed, besides occasional temporary laborers.

"Und ebenso begreiflich war es, dass ein junger Mann, der gerade damals die Universität bezog, um sich zoologischen Studien zu widmen, von dieser Erregung ergriffen ward, und sein ganzes weiteres Leben an die Aufgabe setzte, die materiellen Schwierigkeiten der Forschung zu verringern und durch zweckmässige Organisation die intellectuelle Arbeit in weitestem Umfange zu erleichtern. Diese führte zur Gründung der Zoologischen Station in Neapel."[a]

Foremost among the biological stations of the world in the extent and completeness of its material equipment and in the wealth of opportunities it offers, inspiring in its history and unparalleled in its growth, unsurpassed in its contributions to biological science, profound in its influence upon the course of development of modern biology, and powerful in its stimulus to the establishment of biological stations elsewhere, stands the zoological station of Naples, the peer and leader of them all. Coming as a foreign intruder into a strange city, it has won the pride and confidence of Naples; beginning upon slender private means, it now draws its funds in large part from state budgets and from educational and scientific institutions in many lands; primarily and completely German in origin and spirit, it is nevertheless international in support and clientele and is to-day one of the pleasing visible tokens of the banishment of political boundaries in the world of science.

The Naples station is no chance offshoot in the rapid growth which the biological sciences have made in the past forty years, nor a mere expression of the scientific Zeitgeist, but rather the creation of the single indomitable spirit of Anton Dohrn. The fact that it is thus a personal creation makes it difficult, indeed impossible, to relate its whole history. Suffice it to say that his zeal for the enterprise, the high standard of service inculcated in all of its departments, the superb esprit de corps maintained in the organization, and above all the indomitable courage of the founder, have turned bankruptcy to

[a] Anton Dohrn (1892).

financial success, dispelled the suspicions of an alien people of an enterprise they could but imperfectly understand, has commanded and held the loyal support of the German State and the fishermen of Margellina and has made Naples the Mecca of the biological world.

This great work has been accomplished without involving the station in any entangling alliances with other institutions or with economic interests. Throughout all its history the station has preserved its integrity and its untrammeled freedom from all control save that of its director.

A pupil and colleague of Ernst Haeckel and docent at the University of Jena, young Dohrn made in 1868 a journey to the coast of Sicily and established at Messina a small temporary laboratory for his own researches. Returning to Germany in the winter he began the collection of funds to open a laboratory and aquarium at that place, but, fortunately, as recent history has so tragically proved, he changed his selection of location to Naples. In 1870 he finally succeeded in securing from the city of Naples a superb site in the Villa Nazionale on the water front of the Bay of Naples, upon the condition that he should erect a station which remains the private property of the founder and his immediate heirs for ninety years and then reverts to the municipality, but must still be used for its original purpose.

The Franco-Prussian war delayed operations, but building was begun in 1872 and completed in 1874, when the station was formally opened in February, after months of harassing difficulties, local, technical, and financial. In this first building Doctor Dohrn sunk his private fortune of 300,000 francs, the balance of the total cost of 400,000 being met by outside contributions, of which £1,000 was secured in England through the efforts of Mr. Frank Balfour and Professor Huxley. The German ministry of foreign affairs granted an annual subvention of 30,000 marks (increased in 1888 to 40,000 marks, and later reduced to 20,000 upon Doctor Dohrn's initiative), and the station was launched on its successful career.

The increasing demands upon the station compelled an enlargement of its facilities in 1886 by the construction of the western block of the building (Pl. III, *A*), toward the cost of which the Italian and provincial governments contributed through several yearly budgets a total of about 100,000 lire.

In the original plan of the station, as outlined by Doctor Dohrn (1872), comparative physiology was included in its proposed field of investigations, but funds were insufficient to provide adequate equipment. It was not until 1903 that the project of expansion for this rapidly growing branch of biological science was undertaken. With the encouragement of the German Emperor a fund of 300,000 marks was subscribed toward the erection of the magnificently constructed and equipped new section of the building, devoted in large part to

comparative physiology and physiological chemistry. This increase of facilities has doubled the working room of the station and made it possible for it to meet the greatly increased calls upon it, a demand which for several years prior to 1905 exceeded its resources.

The Naples station has been exceptionally fortunate in the men who have been associated with Doctor Dohrn in the enterprise. Prominent among those who have served upon its staff is the name of Dr. Hugo Eisig, Doctor Dohrn's loyal lieutenant from the very first (1871) and still an emeritus member of the staff. Among those who in the earlier years contributed to the growth of the station are Kleinenberg, Spengel, Lang, Schmidtlein, Andrés, Vosmaer, Brandt, Falkenberg, Berthold, Herter, Schönlein, Raffaele, Schiemenz, and List, besides a series of eminent men who as collaborators and authors of the monographs in the "Fauna and flora" have been in more or less extended residence at the station.

The present staff includes, in addition to the director, in whose hands lies the entire control of the station in its complicated external relations and manifold and multiform activities, a permanent staff of ten—a faculty, as it were, of this "marine university." There is no elaborate system of internal organization, no complicated bureaucratic system, but rather a well-balanced subdivision of labor among cooperating and mutually helpful departments whose heads have been carefully chosen with a view to scientific efficiency and the maintenance of that subtile esprit de corps, that atmosphere of courtesy and freedom that tends to call forth the finest effort from every devotee in its quiet laboratories.

The zoological department is presided over by the genial Paul Mayer, who since 1877 has counseled and guided more than a generation of zoologists who have profited by his justly renowned skill in and wide and critical knowledge of the complicated technique of modern morphological investigations. In charge of this department are all those pursuing zoological work in the broad sense of the word, whether systematic, morphological, embryological, or experimental. In this work, as also in that upon the "Zoologischer Jahresberichte," of which he has been editor since 1881, Professor Mayer is assisted by Dr. J. Gross.

The maintenance of the high standard of excellence in the publications of the station which contain its contributions to science—the series of quarto monographs of the "Fauna and flora" and "Mittheilungen"—is due to the skillful editorship of Professors Mayer and Giesbrecht. In charge of the latter are also the artists employed in the preparation of illustrations for the monographs and articles by the staff in the "Mittheilungen" and the supervision of the lithographic and other illustrations used in the series.

A. THE STATION IN 1909, FROM THE SOUTHWEST.

Photograph from Doctor Lo Bianco.

B. MAIN ENTRANCE TO THE AQUARIUM.

Photograph by Doctor Schöbel.

THE NAPLES ZOOLOGICAL STATION.

The care of the ever-increasing library falls to the hands of Doctor Schöbel, whose professional knowledge of biology greatly facilitates the care of this rich resource of the station and its use by the newcomer. His technical skill in photography is of great service to the station, and the ateliers are in his charge.

Unique among the features of the Naples station is the prompt and efficient provision of living booty from the sea for study and research. Upon the morning of arrival the expected naturalist finds upon his table a collection of preserved material, it may be, or a dish of fresh sea water with some brilliantly colored squirming inhabitant of the subtropical Gulf of Naples, brought that morning by a barefooted fisherman from Margellina, Posilippo, Procida, or perhaps distant Capri or Ischia. But one may rest assured that the material will be there unless Neptune and Boreas are angry, or the "sirocco" drives even the amphibious Neapolitan fisherman to land. Every morning at 10 o'clock the ten or more fishermen of the station, with buckets or baskets full of glass jars poised gracefully on their heads, march into the court and receiving room of the station with their prizes from the sea—scarlet starfishes, orange feather stars, red and black sea-cucumbers, sea-urchins, squirming serpent stars, and bristling purple sea-urchins; or it may be a bit of red coral or a wriggling creeping octopus. No less interesting and wonderful for beauty of form and color are the translucent, shimmering colors of the violet Velella, the bandlike phosphorescent Venus's girdle, or the brilliant domes of the medusæ. Equally prized by the naturalist is the great array of less highly colored and the seemingly uninteresting worms, crabs, and amorphous sponges, or even the brown slime that the nets of finest silk sift from the blue waters of the bay. Along with the fishermen of the station come others silently offering their wares—some rare prize, or merely the inedible waste, the few types of marine life, without value at the mercato, which his nets have yielded, for the Neapolitan fisherman has long since learned that such spoils have a value and a sure market at the station. The varied material thus assembled is speedily distributed to the specialists for investigation, sent to the exhibition tanks, or preserved for shipment to museums and biological laboratories.

The organizing and directing spirit in this complex but absolutely fundamental activity of the station was Dr. Salvatore Lo Bianco, Naples's own contribution to the life of the station. Joining the staff of the station as a laboratory boy at the age of 13, his native talents quickly attracted the attention of Doctor Dohrn, and under his tutelage and encouragement he became, without the aid of schools or universities, a skilled linguist and biologist and an investigator of wide fame. His knowledge of the local and seasonal distribution of the fauna and flora of the Gulf of Naples has been one of the indispensable

elements in the daily life and work of the station. His cheery greeting as he made the daily round of the laboratories to learn the needs of the three score and ten investigators, and his versatile talents, whether seen administering discipline—in Neapolitan—to some unruly member of his motley crew, or as the genial host at the trattoria on the Vico Pasquale, or singing "John Brown" to the strumming of his guitar on an "Ausflug" of the "Johannes Müller," endeared him to the biologists of many nations.

The crowded state of the station prior to its extension in 1905 prevented the development of any extensive collection of marine life for exhibition or reference, but this department will be taken up by Dr. R. Gast, whose superb casts of marine animals have achieved great success in artistic circles.

No botanist is at present attached to the station.

The newly erected department of comparative physiology, with its profoundly important relations to human and comparative medicine and its superb instrumental equipment, is under the able direction of Dr. R. Burian, while Doctor Bauer acts as zootomical assistant to aid those students of physiology who have no adequate knowledge of the anatomy of the marine forms with which they wish to work. For this purpose a series of anatomical papers dealing with forms most used in experimental operations have been begun by Doctor Bauer. The first, upon the Cephalopoda, has been published (1909), and many drawings for later subjects are already available for workers in physiology.

The department of physiological chemistry, working in close conjunction with that of physiology, is under the guidance of Dr. M. Henze, a chemist of wide experience in the organic field.

The correspondence and business affairs of an institution having such varied interests and relations with so many persons and institutions are sufficient to demand the services of an experienced secretary, Mr. Hermann Linden, through whom all business with the authorities of the city, post, telegraph, railway, customs, and public utilities is carried on. He also conducts the correspondence with appointees to the various tables, and, through the station, is of great service to foreigners on arrival in all matters pertaining to hotels, pensions, baggage, customs, etc.

The complicated technical problems which arise in a large scientific institution, such as the Naples station, afford scope for the employment of a trained engineer and architect, Mr. E. Gravina, who has charge of the building and the equipment and the construction of all new fittings and apparatus. The Naples station has adopted the seemingly expensive method of constructing much of its own equipment, and the engineer has, accordingly, a staff of trained mechanics who are kept busy throughout the year. The

familiarity thus gained with the needs of the station, the improvements made, the promptness and certainty with which work can be accomplished, and above all, the saving in the time of the staff otherwise required in supervision, more than justify the expense.

The Naples zoological station is a private institution, the property of its director, and is unique accordingly in its origin, support, and administration. The only restrictions upon the powers of the director are those under which the site in the public park was granted to the station, insuring the use of the building solely for scientific purposes. The station is not officially attached to any other institution, educational, political, or economic, and has thus escaped the evils of bureaucratic control, and, having a strong executive, it has not needed such supervision to insure its success. An annual report to the German minister of foreign affairs by the director is the only external obligation of the station.

The income of the station is derived in part from the rental of tables, which yields about 125,000 lire annually, and the receipts from admissions to the aquaria, which fluctuate largely with the number of tourists visiting Naples. Receipts from this source (admission, 2 lire) average about 50,000 lire yearly, but the cost of maintenance is a very heavy item in the total expenditures (200,000 lire) of the station.

A unique feature of the Naples station is the "table" system of support. The station undertakes for $500 per annum to provide research privileges for one person throughout the year. Tables are not rented for less than a whole year. The considerable amount of this rental has naturally thrown the burden of providing for it upon state and educational authorities, and scientific organizations of a permanent sort. The result is that the station has a regular and certain support, and is enabled to run continuously year after year, while a much larger number of biologists can thus make use of its facilities, being relieved of the necessity of supporting both themselves and the enterprise.

It is this feature of the Naples station which has made it from the beginning an international institution and has drawn investigators to it from practically all civilized lands. At present there are fifty tables under annual subscription. Prussia supports four tables and Bavaria, Saxony, Württemberg, Baden, Hesse, Hamburg, and the University of Strassburg each, one. The German complement of eleven tables is, however, increased to twenty-two. because of the annual subvention of 20,000 marks from the German foreign office. Of the remaining twenty-eight tables, Italy controls eight through the minister of public instruction, one through the minister of agriculture, three, by the province of and one (furnished gratis) by the city of Naples. Russia supports four, Austria two, Belgium two,

Holland two, Hungary, Switzerland, and the Roumanian Academy one each. There are three English tables supported by the universities of Cambridge and Oxford and the British Association for the Advancement of Science. The Scandinavian countries, France, Spain, Greece, and Turkey are practically the only European countries not supporting tables regularly.

There are at present five American tables. Of these one has been supported by the Smithsonian Institution at Washington since 1893; one by the Carnegie Institution since 1903; and one by Columbia University intermittently since 1896. An American table was also supported in 1883 by Williams College, in 1885 by the University of Pennsylvania, from 1894 to 1896 by Mr. Alexander Agassiz, and in 1891–1895 by Major Davis.

On the occasion of the twenty-fifth anniversary of the founding of the station, the American women (Dr. Ida Hyde and others) who had enjoyed the privileges of Doctor Dohrn's institution started a movement to endow a woman's table at the station. It resulted in a permanent organization, "The Naples Table Association for Promoting Laboratory Research by Women," which since 1898 has maintained a table by annual subscriptions of $50 each.[a] The year of the association begins in April, and all applications for the following year should be sent to the secretary on or before March 1. The appointments are made by the executive committee.

A prize of $1,000 has been offered periodically by the association for the best thesis written by a woman, on a scientific subject, embodying new observations and new conclusions based on an independent laboratory research in biological, chemical, or physical science. The third prize was awarded in April, 1909.

Application blanks, information in regard to the advantages at Naples for research and collection of material, and circulars giving the conditions of the award of the prize were furnished by the secretary.[b]

The woman's table is equipped with a Zeiss microscope with achromatic objectives, a camera lucida, and a large Zeiss dissecting microscope of the latest model.

Since its foundation over twenty American women have enjoyed the privileges of this table. Thus, indirectly, the Naples station

[a] For the year 1908–9 the following colleges, associations, and individuals were contributors: Association of Collegiate Alumnæ, Western Reserve University; Barnard College, Bryn Mawr College, University of Chicago, Massachusetts Institute of Technology, Mount Holyoke College, Radcliffe College, Smith College, University of Pennsylvania, Vassar College, Wellesley College, Women's College in Brown University, Women's Advisory Committee of the Johns Hopkins Medical School, Woman's College of Baltimore, Miss Helen Collamore, Mrs. Alice Upton Pearmain, Mrs. J. M. Arms Sheldon, Mrs. Elizabeth A. Shepard, and Mrs. Mary Thaw Thompson.

[b] Executive committee of the association is composed of the following: Dr. Lilian Welsh, The Arundel, Charles street, Baltimore, Md., chairman; Miss Lida Shaw King, Brown University, Providence, R. I.; Miss Sarah E. Doyle, 119 Prospect street, Providence, R. I.; Mrs. Alice Upton Pearmain, 388 Beacon street, Boston, Mass.; Miss Caroline Hazard, Wellesley College, Wellesley, Mass.; Mrs. Elizabeth L. Clarke (Mrs. S. F.), Williamstown, Mass., treasurer; Mrs. Ada Wing Mead (Mrs. A. D.), 283 Wayland avenue, Providence, R. I., secretary.

A. MAIN LABORATORY OF COMPARATIVE PHYSIOLOGY.

Photograph by Doctor Schöbel.

B. OPERATING ROOM, LABORATORY OF EXPERIMENTAL PHYSIOLOGY.

Photograph by Doctor Schöbel.

LABORATORIES, NAPLES STATION.

through the American woman's table has been and is an important means of stimulating the higher education of women in the United States.

Doctor Dohrn's personal letter to Doctor Hyde in response to this enterprise on the part of American women is a unique document in the history of the higher education of women and is by permission printed here.

NAPLES, ZOOLOGICAL STATION, *April 20, 1897.*

DEAR MISS HYDE: Among all congratulations and honors come to me in these days, there is almost none which caused me such surprise and also such great joy as your kind letter.

Personal acknowledgment is always sure to come, when success has been secured, and if such acknowledgment has come in a far greater amount than I have merited and ever dreamed of, I am indebted to the kindness of high and low, with whom I had intercourse in the long run of these twenty-five years. Even emperors and kings are mortal men and are open to the feelings of friendship; no wonder that they seize an opportunity to show it, together with other proofs of their well-wishing. And academies, universities, and scientific bodies have a feeling of comradeship and their congratulations have come to one of their own flock.

But that American ladies gather together and collect money to establish a table in the zoological station, to honor its twenty-fifth anniversary, is such an astounding proof of sympathy that I am quite amazed at it, and embarrassed beyond measure how to account for it.

Let me openly and sincerely confess that it has taken long years to persuade or rather convince me that the modern movement in favor of women's emancipation is a sound one. In fact, I am only half open to belief in a successful end of it, and would be glad if it went on in a more moderate degree than usually proclaimed; but there is one part of it for which I have not hesitated to feel and confess a strong sympathy, that is, the throwing open to women the pursuits of science and the higher intellectual development. I do not only believe women capable of higher intellectual training, but think it will be of the utmost advantage to them and to mankind when wives and mothers share in those accomplishments, which make a difference in the educated and non-educated intellect. To share the life of an intellectual husband, and prepare the future generation, are tasks that require the best instruction and mental education. Thus I have always felt it my duty to act upon my convictions, and have always received ladies in the zoological station with the same readiness as men, and from the first, ladies have worked in it, and at present one is here at work. I did not anticipate that my quiet way to help them in this, their right, should have such an answer as you announce in your letter. But such is the effect of true conviction, that it moves others to acknowledge it. You know there is a German poetical saying:

> "Es ist der Fluch der bösen That, dass sie
> Fortzeugend Böses muss gebären."

But also it is the blessing of a good action that it produces other good actions, and as such a good action, my slowly but firmly established belief in the necessity of granting women their full share of intellectual training has produced in you and the committee the friendly feeling for the zoological station, and the resolution to help in its development.

I thank you for this sympathy and for your energetic embodiment of it in the way that you announced.

At any rate, permit me to thank you, and confer my thanks most heartily and sincerely to all of the women who have honored me and the zoological station by their efforts.

Believe me, yours, most thankfully and respectfully,

(Signed) ANTON DOHRN.

The number of American biologists who have availed themselves of the privileges of the Naples station since 1883 is 125. The debt which American science owes to the institution is thus no small one, for repeatedly the American attendance exceeds the number of American tables under subscription, and at such times Doctor Dohrn has always freely provided places for all who came, since tables are not always occupied throughout the year.

The international character of the Naples station is well shown in the sources of its clientele as appears from the statistics of attendance since September, 1873. Up to April, 1909, there had been 1,934 occupants of research tables, including repetitions of occupancy. They are distributed as follows, according to their countries of residence.

Attendance at Naples station, by countries, 1873–1909.

Germany	630
Italy	481
Russia	163
England	153
Austria	119
United States	111
Switzerland	76
Holland	72
Belgium	58
Hungary	30
Spain	18
Denmark	10
Roumania	7
France	4
Bulgaria	2

The following is the American attendance since 1883, arranged by years:

American attendance at Naples station, 1883–1909.

1883. E. B. Wilson
1884. F. W. Clarke.
1888. C. S. Dolley, W. Patten.
1891. H. F. S. Russell, Miss J. B. Platt.
1892. E. B. Wilson, G. W. Field.
1893. G. H. Parker, G. H. Fairchild, W. M. Wheeler.
1894. C. W. Hargitt, J. H. Gardiner, H. C. Bumpus, L. Murbach, T. H. Morgan, H. Osborn, E. F. Rice, C. M. Child, W. E. Ritter.
1895. J. Reighard, C. C. Nutting.
1896. W. T. Swingle, J. M. MacFarland, F. H. Herrick, R. S. Harrison, W. R. Coe, A. W. Weysse, A. P. Matthews, Miss Ida Hyde.
1897. J. Y. Graham, E. O. Hovey, E. Meek, H. S. Jennings, H. V. Neal, Bradley M. Davis.
1898. W. H. Conn, D. M. Mottier, W. T. Swingle, J. H. Gerould, Miss Mary Wilcox, Miss Florence Peebles.
1899. E. B. Wilson, F. B. Sumner, F. W. Bancroft, E. L. Mark, Misses S. Nichols, E. Gregory, H. Snowden.
1900. V. Heiser, B. M. Duggar, T. H. Morgan, C. Mensch, C. F. Hottes, T. B. Sumner, W. T. Parker.
1901. T. Stevens, R. Burton-Opitz, Misses C. Clapp, L. Wallace, F. Peebles, N. Stevens.

1902. M. Sweet, C. W. Prentiss, T. H. Morgan, C. M. Child, E. P. Lyon, F. M. MacFarland, C. B. Davenport, C. Zeleny, W. A. Locy, C. S. Minot.
1903. C. W. Hargitt, C. R. Bardeen, W. H. Lewis, E. B. Wilson, H. S. Jennings, G. Cooley, Miss A. Barrows.
1904. G. Cooley, V. E. Metzger, J. B. Johnston, Bradley M. Davis, E. B. Wilson, G. S. Pierce, R. S. Lillie.
1905. C. E. Allen, A. A. Blakeslee, S. Paton, W. B. Bell, Frau Boveri, Misses H. Lehrmann, H. Sherman.
1906. H. Heath, C. D. Snyder, N. Yatsu, R. Pearl, Miss G. B. Watkinson.
1907. E. L. Rice, A. Gulick, E. C. Starks, A. G. Mayer, M. M. Metcalf, S. Paton. Misses G. B. Watkinson, A. G. Newell, F. Peebles.
1908. J. F. Lewis, F. M. Andrews, E. R. Downing, C. S. Mead, H. S. Colton.
1909. H. S. Colton, S. Paton, S. Yamanouchi, C. A. Kofoid, F. M. Guyer, Misses E. Torelle, N. M. Stevens, A. M. Boring, W. N. Nowlin.

The conception originally in the mind of the founder of the Naples station, that it should decrease the material difficulties of investigation and by appropriate organization facilitate the intellectual work of biology in the widest circles, has been rigidly adhered to in the years that have passed. The station is and always has been, purely and solely, a research institution.

For some years past, by a special arrangement with Doctor Dohrn, naval officers and naval physicians of Italy and several other European nations have received instruction at the station in the practical methods of collection and preservation of marine material for biological uses. The collections of the round-the-world cruise of the *Vettor Pisani* were made by officers thus instructed at the Naples station. The example set by Italy and the Naples station in this respect might be followed by other nations with great profit to the cause of marine biology and oceanography and with relatively small expense for the returns, as compared with the cost of special deep-sea expeditions.

The privileges of a research table at the Naples station are secured by lease (for full year only) at a cost of $500, or by appointment to some table by a lessee. As a matter of fact, the latter is the customary method, the appointment being in all cases made by the holder of the lease. Owing to the distribution of university vacations the crowded season is in March and April, during which time several persons often enjoy the privileges of the station under the terms of a single lease. No particular room or field of investigation is attached to any "table," but the distribution of persons is adjusted to the space available at the time and to the line of work chosen by each applicant.

American investigators have the privileges of five tables, three of which are open to general application, one to women specially, and the fifth leased by Columbia University. Applications for the Smithsonian and the Carnegie table should be sent to the secre-

taries of these institutions at Washington, D. C., and for the woman's table to the secretary of the Naples Table Association. (See p. 12.)

To persons coming to the station a circular of information is sent with Doctor Dohrn's advice regarding baggage, customs, hotels, pensions, clothing, food, and hygienic precautions incident to life in Naples, and the few simple regulations governing the use of the laboratories and library. The circular also contains a general list of the equipment, reagents, etc., provided for the botanical and zoological tables and the apparatus available in the physiological and chemical laboratories.

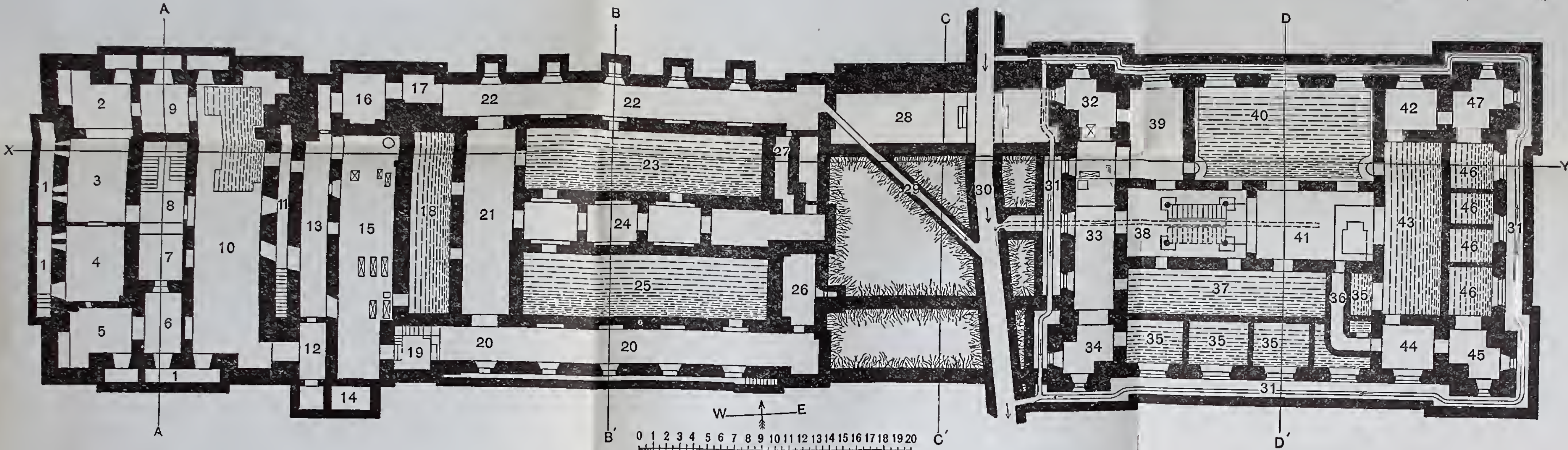
The equipment of the tables for morphological work includes an ample supply of all reagents, preservatives, glassware, aquaria, and drawing materials (except paper and brushes). The following articles are furnished at cost: Alcohol in excess of 5 kilos per three months, excessive amounts of expensive chemicals—such as platinum chloride, osmic acid, cocaine, gold chloride, etc.—slides, cover glasses, and containers. The equipment for physiological and chemical work is furnished according to the subject of investigation.

Living material for investigation is promptly provided, weather and season permitting, as needed, but only in exceptional cases can the cost of collection, which obviously varies greatly with the nature of the beasts sought and with environmental conditions, be allowed to reach 100 lires per month. Boats with oarsmen, for collecting excursions when these are necessary, are also furnished. Free access to the aquarium is granted to all investigators having tables; the use of large tanks for experimental purposes is allowed by special arrangement only. Persons are granted every privilege in securing material for their personal investigations at the station, but are not permitted to make collections for purposes other than this.

The library is open during the day and each person is permitted free access to the books and to withdraw for use in his laboratory not over twenty-four volumes.

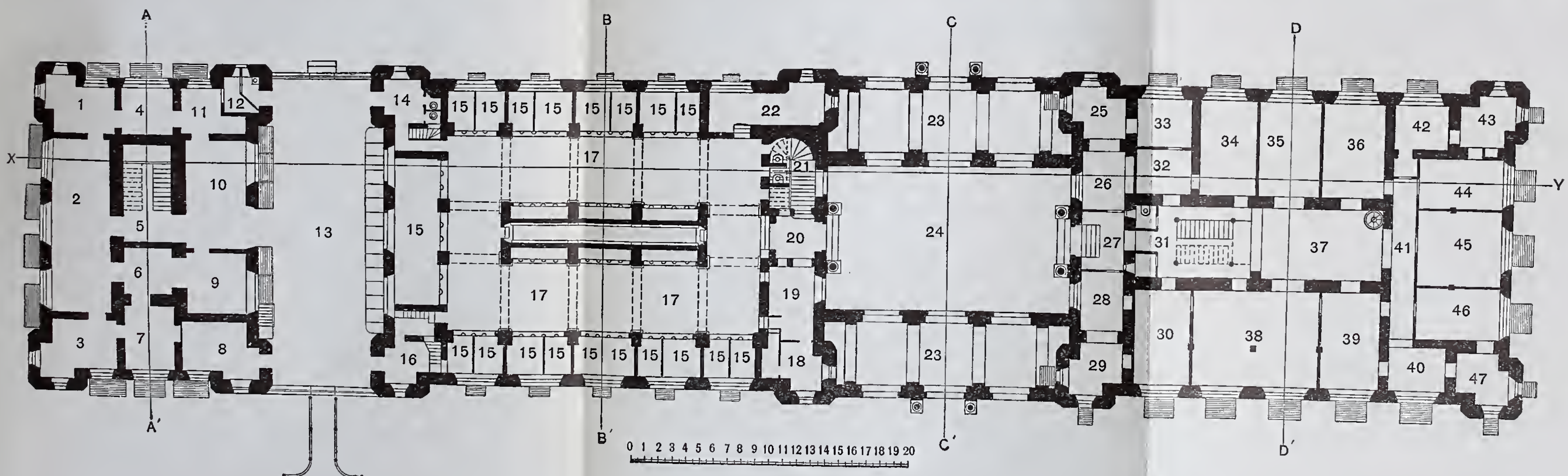
Investigators are expected to provide their own microscopes, microtomes, microtome knives, and the usual personal desk equipment. For the use of American workers, but not attached to any particular table, the station has received from the manufacturer a gift of two high-grade microscopes, each with oil immersion lens. A Minot-Zimmermann microtome has been placed in the station by the American Society of Naturalists for the use of the American tables. Application should be made in advance to the secretary of the station for the use of these instruments.

The station is open to investigators throughout the whole year, week days, Sundays, and holidays, by day, and even by night, by special arrangement, though the staff and employees have the



A. BASEMENT FLOOR.

1, Window areas. 2-9, Cool storerooms. 10, Sand filters for aquaria for developmental mechanics. 11, Passage. 12, Machinist's room. 13, Forge. 14, Window area. 15, Room for motor, boiler, and pumps. 16, 17, Storerooms. 18, Tank, 50 tons capacity. 19, Stairs. 20-22, Passages. 23 and 25, Tanks, 100 tons capacity each. 24, Passage. 26, Storeroom. 27, 28, Passage. 29, Passage to sewer. 30, Main trunk, city sewer. 31, Area, air passage above basement. 32, 33, Motor and pump. 34, Coal room. 35, Storage tanks for physiological department. 36, Passage. 37, Reservoir tank, capacity with No. 35, 70 tons. 38, Stair well. 39, Chemical storeroom. 40, Tank, 100 tons capacity. 41, Steam heating plant. 42, 45, 47, Storerooms. 43, Reservoir. 44, Centrifuge room. 46, Storage tanks for physiological department, 80 tons capacity.



B. FIRST FLOOR.

1, Net room. 2, Tackle and sorting room. 3, Conservator's laboratory. 4, Stock room for glassware. 5, Stair well. 6, Biological material storeroom. 7, Conservator's office. 8, Machine shop. 9, Biological supply department, laboratory. 10, Receiving room. 11, Alcohol still. 12, Storeroom. 13, Court. 14, Night watchman. 15, Aquarium tanks with overhead passage. 16, Passage and stair. 17, Public aquarium, grotto. 18, 19, Offices of aquarium. 20, Entrance to aquarium. 21, Stair well. 22, Breeding room for fish larvæ. 23, Arched passageways. 24, Open court. 25, 26, Carpenter shop. 28, 29, Mechanician for physiological department. 30, Zoological laboratory, 2 tables. 31, Stair well. 32, 33, Mechanician's drafting rooms. 34, Galvanometer dark room. 35, Dark room for experiments with light. 36, Dark room with large galvanometer. 37, Hall. 38, Zoological laboratory, 4 tables. 39, Light room for experimenting with sunlight. 40, Zoological laboratory, 2 tables. 41, Passage, with overhead cement tank for low-level laboratories. 42, Dark room for photography for galvanometer work. 43, Microphotographic dark room. 44, Thermostat room for biological work with constant temperatures. 45, Zoological laboratory, 2 tables. 46, 47, Zoological laboratories, 1 table each.

BASEMENT AND FIRST-FLOOR PLANS, NAPLES STATION. BY COURTESY OF THE NAPLES STATION.

usual working hours and holidays. The climatic conditions are pleasantest in the spring, at the season of the Easter recess of continental universities, so that the station is apt to be crowded from March to May. Persons whose material for investigation can be obtained at other seasons than spring are sure of finding their accommodations at the station, but those who must come in spring months should engage their tables some time in advance.

The whole facies of the museums of the world, in so far as they represent the life of the sea, has been changed by the magnificent collections sent out from the supply department of the Naples station, or prepared elsewhere according to the methods elaborated by Signor Lo Bianco, late conservator of the station. Instead of the contracted, distorted, misshaped, and sometimes mutilated specimens, which all too often in earlier years misrepresented in our museums the wonderful beauty and symmetry of life in the sea, we find to-day, preserved in normal form and perfection of parts, a wide range of marine invertebrates, including many which formerly eluded all attemps at preservation. An account of the methods by which these results have been achieved has been published by Signor Lo Bianco (1890) and reprinted in translation, with additions by Dr. E. O. Hovey, in Bulletin 39m of the United States National Museum (1899). The perfection attained at Naples rests upon the securing of the material in perfect condition, the use of living material, the careful adaptation of methods to each particular animal in order to secure the best results attainable, and the long experience of the conservator and his corps of assistants in the manipulation of the delicate animals from the sea. The wide knowledge which Signor Lo Bianco had of the local fauna and flora, the wealth of material at his command, and his staff of experienced collectors placed the Naples station in a position unsurpassed among the stations of the world in its facilities for supplying superbly prepared material for exhibition purposes or for research. Material for histological or cytological investigation, fixed and preserved according to any desired formula, is also furnished on order. A price list of material, in stock or occasionally available at Naples, containing the names of over 1,000 species, is sent upon request. The service which the station renders to biological science throughout the world by this department of its work is no inconsiderable one.

The Naples station has no formal relation to the fisheries or fisheries bureau and undertakes no economic research. However, much work of fundamental significance with respect to the fisheries has been prosecuted within its walls. Not the least of these is the work of Signor Lo Bianco (as yet largely unpublished) upon the larval stages and young of the fishes of the Bay of Naples and vicinity. This work is based in large part upon the successful rearing of fish

from the youngest larval stages to the adult. The station possesses a room specially equipped for this work.

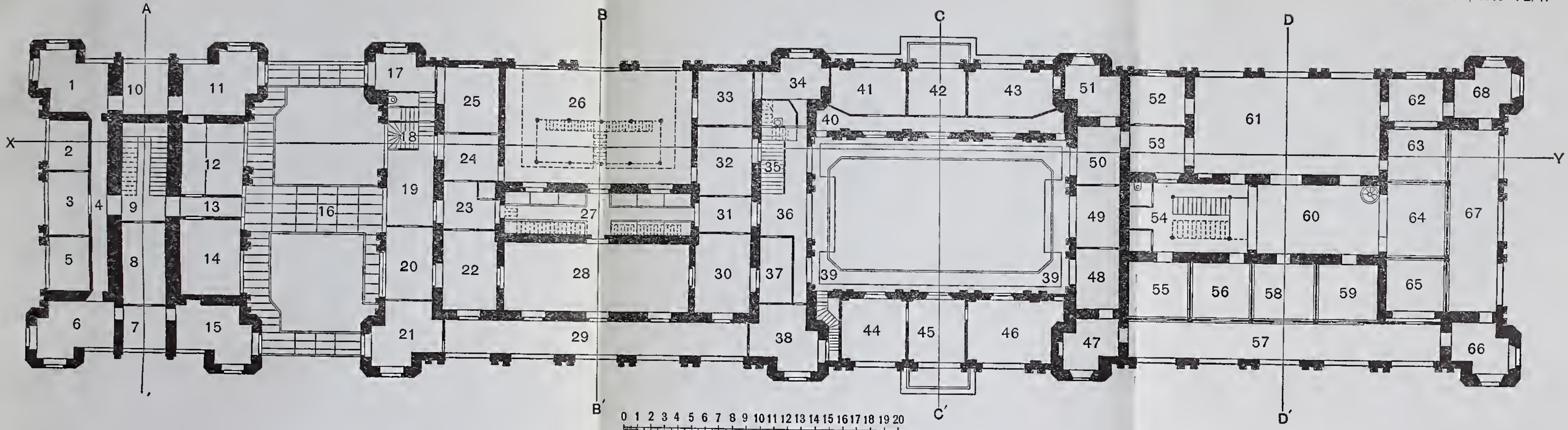
The lines of investigation pursued at the Naples station are as varied as the field of marine biology, and the results have been published in all lands whence investigators come to Naples. In fundamental accord with the spirit of freedom prevailing in the institution and in consonance with Doctor Dohrn's original desire to facilitate research in the widest sense, no efforts are made to direct the lines of the research pursued by those who occupy the tables. No instruction is offered. Occupants of tables are supposed to have been trained in the sciences which they are pursuing. The field of investigation and place of publication is left to individual initiative. The investigations of the staff of the station, on the other hand, are directed into those fields which tend to facilitate the work of others.

Foremost among these efforts is an annual summary of the whole field of morphological zoology issued promptly and written by specialists in the several groups, the "Zoologischer Jahresbericht" (1879 +), edited (1879–1881) by J. Victor Carus, P. Mayer, and W. Giesbrecht, later (1882–1885) by Mayer and Giesbrecht, and since 1886 by Mayer. The assistance rendered to research by these authoritative and prompt reviews was greatly needed and is invaluable in facilitating investigation and forestalling duplication of effort.

A second enterprise of greater magnitude and one involving great expense is the magnificent "Fauna und Flora des Golfes von Neapel und der angrenzenden Meeresabschnitte," a quarto series illustrated superbly with colored lithographed plates. This publication contains a series (31 up to 1908) of monographs dealing exhaustively with the various groups of animals and plants found in the Bay of Naples. In addition to the far-reaching service rendered by this concrete example of intensive research, the finest flower of German zoological investigation, the monographs serve to reveal the wealth of material found at Naples and to facilitate further investigation on these groups elsewhere and in other than morphological lines.

The third serial publication, the "Mittheilungen aus der Zoologischen Station zu Neapel, Zugleich ein Repertorium für Mittelmeerkunde" (1879 +), now in its nineteenth volume, contains the less extensive researches made at the station which add to the knowledge of the Mediterranean fauna and flora.

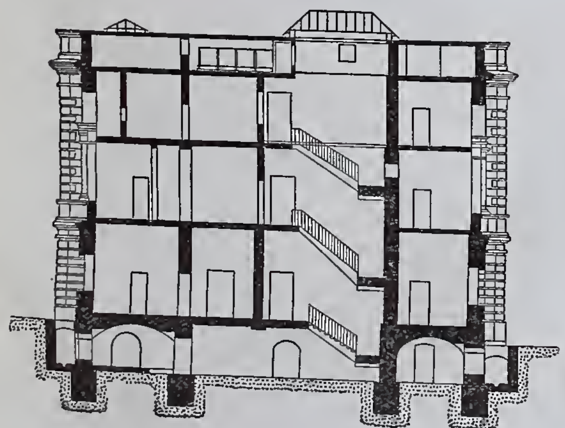
The station has not as yet undertaken any systematic exploration in the nature of a biological survey, or continuous and correlated exploration, of pelagic, abyssal, or littoral fauna, though much of the work of collection, the records of seasonal occurrence, and the individual researches thus far published afford a basis for the beginning of such enterprises. The great wealth of the fauna and the



A. SECOND-FLOOR PLANS, NAPLES STATION.

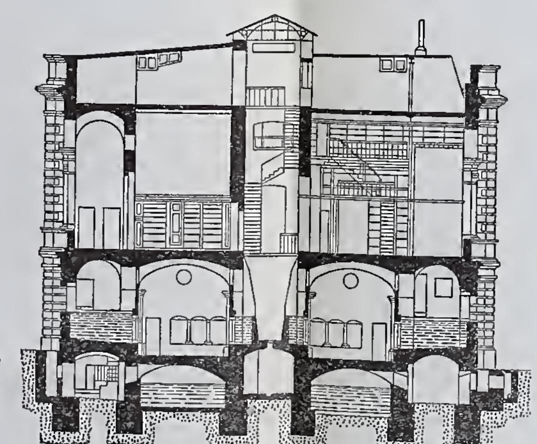
1, 6, 11, 15, 17, Zoological laboratories with 2 tables each. 2, 3, 5, 6, 8, 10, 12, Zoological laboratories with 1 table each. 4, Passage. 7, Loggia. 9, Stair well. 13, Passage. 16, Bridge. 17, Chief laboratory servant. 18, Stair. 19, Toilet. 20, Reagent room. 21, Assistant's room, Doctor Gross. 22, Director's office and laboratory. 23, Passage and telephone. 24, 25, Assistant's rooms, Prof. Paul Mayer. 26, Library, periodicals. 27, Light shaft and passage. 28, Library for general works and reprints. 29, Loggia. 30, Librarian, Dr. E. Schöbel. 31, Passage. 32, Archives, fireproof room for documents. 33, Library workroom. 34, Engineer. 35, Stair. 36, Passage. 37, Porter. 38, Secretary's office, Mr. H. Linden. 39, 40, Passage. 41, Botanical laboratory, 2 tables. 42, Botanical culture room for marine algæ. 43, Botanical laboratory, 2 tables. 44–46, Zoological laboratories, 2, 1, and 2 tables, respectively. 47, 48, Director, Dr. Reinhard Dohrn. 49, Passage. 50, 51, Zoological laboratories, 1 table each. 52, Servant for physiological laboratory. 53, Wash room. 54, Stair. 55, Zootomical assistant for physiological department, Dr. V. Bauer. 56, 58, 59, Physiological laboratories, 2 tables each. 57, Loggia. 60, Operating room. 61, Main physiological laboratory. 62, Assistant in charge of physiological department, Dr. R. Burian. 63, 65, 66, 67, Physiological laboratories with 1, 2, and 1 table, respectively. 64, Loggia. 68, Doctor Burian.

A——A′



B. CROSS SECTION AT A—A′.

B——B′



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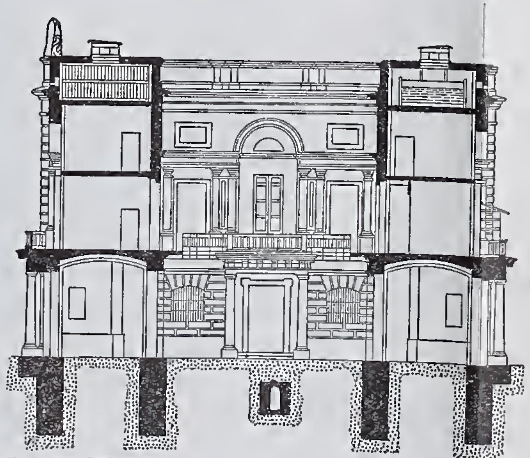
C. CROSS SECTION AT B—B′.

C——C′



D. CROSS SECTION AT C—C′.

D——D′

E. CROSS SECTION AT D—D′.

extreme diversification of the shores and bottom of the Bay of Naples and Tyrrhenian Sea make the attack upon these problems at Naples a colossal undertaking, calling for large resources in men and funds.

A beginning in the exploration of the pelagic area was made in 1901–2 through the munificence of Herr F. A. Krupp, the famous gunsmith of Essen, whose winter home on the island of Capri had made him love the blue waters about him and led him to equip the yacht *Maia*, and later the steamer *Puritan*, to explore their depths. Under the guidance of Signor Lo Bianco there was put into service an equipment including a Le Blanc sounding machine, a full outfit of plankton nets, and large specially constructed closing net of new pattern, built at the Krupp works. Preliminary accounts of these explorations have appeared in the Mittheilungen (Lo Bianco, 1901, 1903), and the first volume of the results has been published (1904). The whole enterprise was unfortunately terminated by the death of its supporter in 1902, and in the absence of a suitable vessel and funds to continue the work the whole equipment lies idle in storage at the station.

The station (Pl. I, *A*) is located near the center of the Villa Nazionale, the famous promenade of the city along the shore of the beautiful Bay of Naples, which sweeps in graceful curve from Capo di Posilippo to the crumbling towers of Castel del Ovo. Embowered in the live oaks of the long promenades and guarded by sentinel palms its glistening walls stand out in the dark foliage of the Villa as one looks down upon it from the Via Tasso or from the Belvedere at San Martino. Its location is central with respect to trams. It lies near the new and more sanitary tourist quarter of Naples, not far from Parco Margherita and the hotels and pensions most frequented by visiting naturalists. The adjacent quarters in the lower parts of the city afford the visitor an everchanging insight into Neapolitan life, picturesque and interesting in the midst of its dirt and squalor.

Plates III–VI give the floor plans, and the accompanying explanations designate fully the purposes to which the various rooms are devoted.

The building (Pl. I, *A*) is a four-story structure in the style of the modern Italian renaissance, built of tufa masonry with stucco trimmings. It is of rectangular form, with its long axis running east and west and fronting toward the sea. Crowning the façade above the main entrance (Pl. I, *B*) is a free relief executed by the sculptor Fritz Behn of a Naiad and Triton (the latter with the likeness of the founder of the station) sporting with the denizens of the sea.

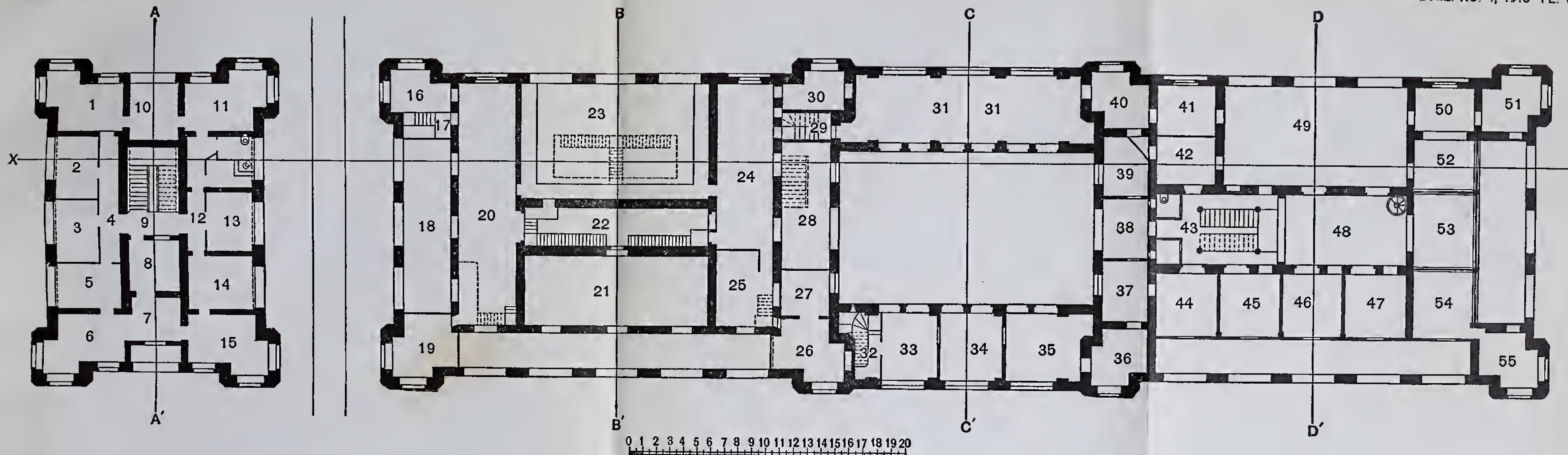
The building (25 by 100 m. and 16 m. above ground in height) is located 75 m. from the sea wall and about 2 m. above mean tide level. It was built after Doctor Dohrn's own sketches and is designed to afford support for high-level water tanks, to provide for a large

number of small well-lighted rooms for research purposes, abundant space for storage, and the manifold subsidiary features which attach to a marine station. The location of the station in a public park necessitated certain architectural concessions in the shape, level, and location of the windows, which in the case of the upper floor and attic interfere with the best illumination, while the crowding live oaks make it necessary to use prism glass for aquarium illumination upon its northern side. For the same reason extensive dark rooms find their location here. The building consists of two detached structures, a western block (25 by 18 m.) containing the biological supply department and the principal zoological laboratories, and a main block (25 by 83.5 m.). The two are separated by an open passage (13, Pl. III, *B*) or court (25 by 18 m.) inclosed in railings and spanned and encircled at the level of the second floor by an iron bridge and promenade. The main block is in itself a symmetrical building, with a middle section (25 by 17 m.) (Pl. III, *B*) containing a central court (24) open to the sky (Pl. IV, *C*, Section C—C′) and reached on both sides at ground level through open archways. Above the arcades formed by these arches the central block is continuous with the rest of the building. On either side the middle section is continuous with a large block (25 by 33.5 m.), each with a loggia (29, 57, Pl. IV, *A*) on the south face. The western block is the original building erected in 1872; the eastern one was built in 1903 for the new departments of physiology and physiological chemistry.

Masonry floors (concrete in the newest part) give great stability for fine microscopical work and the use of instruments of precision, and high ceilings and windows (3.8, 4.2, and 4.8 m. and 7.5 m. in library rooms) in the otherwise small rooms assist both illumination and ventilation. The stair wells in each block are lighted by skylights. (Pl. IV, *B*, *C*, and *E*).

In accordance with the purposes of the station, the building is very much subdivided, the upper floors to provide separately accessible rooms for the seclusion and quiet for individual workers, the basement to carry the weight of the superstructure. The 12,725 sq. m. of space in the five floors contain no less than 46, 46, 68, 55, and 44 rooms, respectively, from attic to basement, a total of 259, including the passages, stairs, attic compartments, etc.

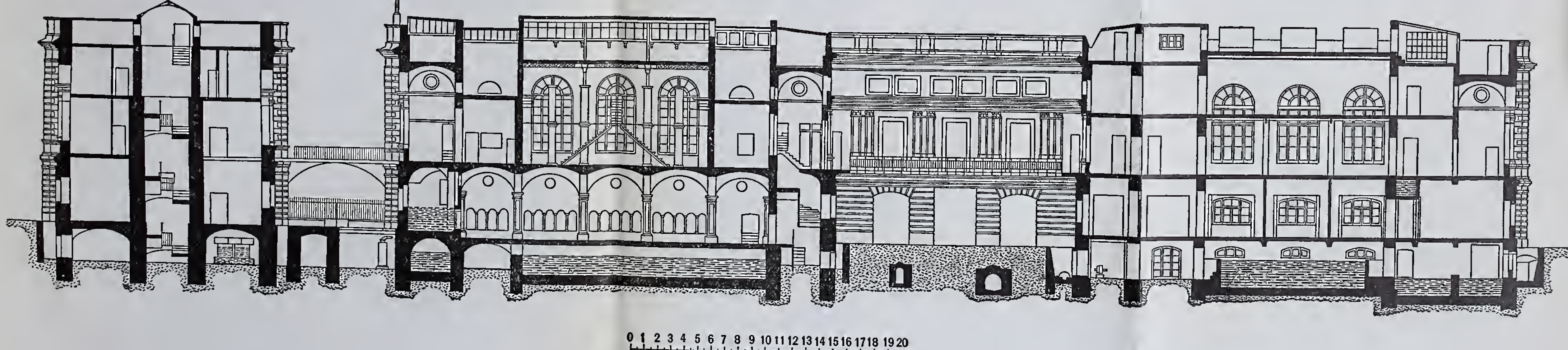
The basement floor (Pl. III, *A*) lies entirely below sea level. It is lighted by area windows and in the latest addition protected and lighted by a continuous area (31). It is excavated throughout, except for a part of the main block adjacent to a large trunk sewer (30) of the city. A wall of extra heavy masonry protects the building against seepage from the sewer. The basement contains the coal storerooms, the main reservoirs (18, 23, 25) for the aquaria, the sand filters (10) for the experimental laboratories, the sedimentation tank (40), low-



A. THIRD-FLOOR PLANS, NAPLES STATION.

1, 8, 7, 11, Zoological laboratories with 2 tables each. 2, 3, Artist's rooms. 4, Passage. 5, 10, Zoological laboratories with 1 table each. 8, Former bacteriological laboratory (closed). 9, Stair well. 12, Passage. 13, Artist's room. 14, 15, Assistant's rooms, Professor Giesbrecbt. 16, Collection room. 17, Stair. 18, Glass reagent storeroom for zoological laboratory. 19, Assistant's room, Doctor Gast. 20, Collection room (in future). 21, Library, upper part of 28 in Plate IV, *A*, frescoes. 22, Light well and stair. 23, Library. 24, 25, Former cbemical laboratory. 26, 27, Assistant's room, Professor Eisig. 28, Upper part of loggia. 29, Stair. 30. Former cbemical room. 31, General zoological laboratory, 6 tables. 32, Stair. 33-35, Zoological laboratories, 2 tables each. 35-55, Cbemical department. 36, Polarization room. 37, Thermostat room. 38, Glass storeroom. 39, Reagent room. 40, Servant's room. 41, Balance room. 42, Wash room. 43, Stair well. 44-47, Chemical laboratories, 2 tables each. 48, Open court on roof. 49, Main chemical laboratory. 50, 51, Gas analysis rooms. 52, Titration room. 53, Organic aualysis room. 54, 55, Assistant's room, Doctor Henze.

X——Y



B. LONGITUDINAL SECTION AT X—Y.

level reservoirs (37, 43) and storage tanks (35, 46) for the physiological department, electric motor and pump in the adjacent passage (33), heating plant (41) and centrifuge room (44), and numerous passages and storerooms. The main pumping plant (15) for the aquaria, which is in almost constant operation, and the smithy (13) are located beneath the court (13, Pl. III, *B*), so that the gases and noise do not enter the building.

The first floor (Pl. III, *B*) contains in the western wing the receiving (10) and sorting (2) rooms, the office (7) and laboratory (3) of the conservator, the tackle rooms (1, 2), the work and store rooms (4, 6, 9, 11) of the biological supply department and the machine shop (8).

The western wing of the main block contains the watchman's room (14), the grotto-like exhibition hall of the public aquarium (17) with peripheral row and central banks of aquaria lighted by central light shaft, the offices (18, 19) and entrance (20) to the aquaria, and the fish-culture room (22). The first floor of the middle section of the main block is entirely open, affording a passageway (23) for the public and entrance to the public aquarium and to research rooms above and adjacent to it. The sewer beneath and the necessity of interrupting the long building in the public park account for the type of construction.

The first-floor entrance (27) of the eastern wing leads into a large centrally located hall and stair well with carpenter shop (25, 26) and mechanicians' workshops (28, 29) on either side. Along the heavily shaded north side are the mechanicians' drafting rooms (32, 33) and the dark rooms (34–36, 42, 43) of the physiological department. On the south and east sides are the zoological (30, 38, 40, and 47, 46, and 45) and physiological (39 and 44) laboratories. Above the cross passageway (41, see also Pl. V, *B*) is a low-level cement tank (capacity about 30 cu. m.) for supplying the laboratories on this floor.

The second floor (Pl. IV, *A*) contains the offices, the library, and many of the investigators' rooms. It is the floor most used and is accordingly provided with ready means of communication. The western block is entirely given up to investigators' laboratories, 12 in all, and is connected by the iron bridge (16) with the central hall (19, 23, 27, 31, 36) traversing the western wing of the main block and passing on light iron gratings through the shaft (27) which lights the aquaria below. In this block are the offices of the director (22), librarian (30), secretary (38), archives (32), engineer (34), of the assistants in the zoological department, Dr. Paul Mayer (24, 25) and Doctor Gross (31), the workrooms of the library (33) and laboratory (17) assistants, the chemical supply room (20) for the zoological department, and the porter's (37) office.

The central part of the building upon both sides of the long hall is occupied by the library (26, 28), which is two stories in height (Pl. IV, *C*). The north room was the former general zoological laboratory of two stories with communicating stair, but since the completion of the last addition to the building it is given over wholly to the periodical department of the library.

On either side of the open court in the middle section is a row of three laboratories (41–46), those on the north side assigned to botanical investigators (the middle one serving as an algal culture room) and on the south side to zoologists. A closed corridor (40) connects the western and eastern wings and an open walk (39) encircles the court.

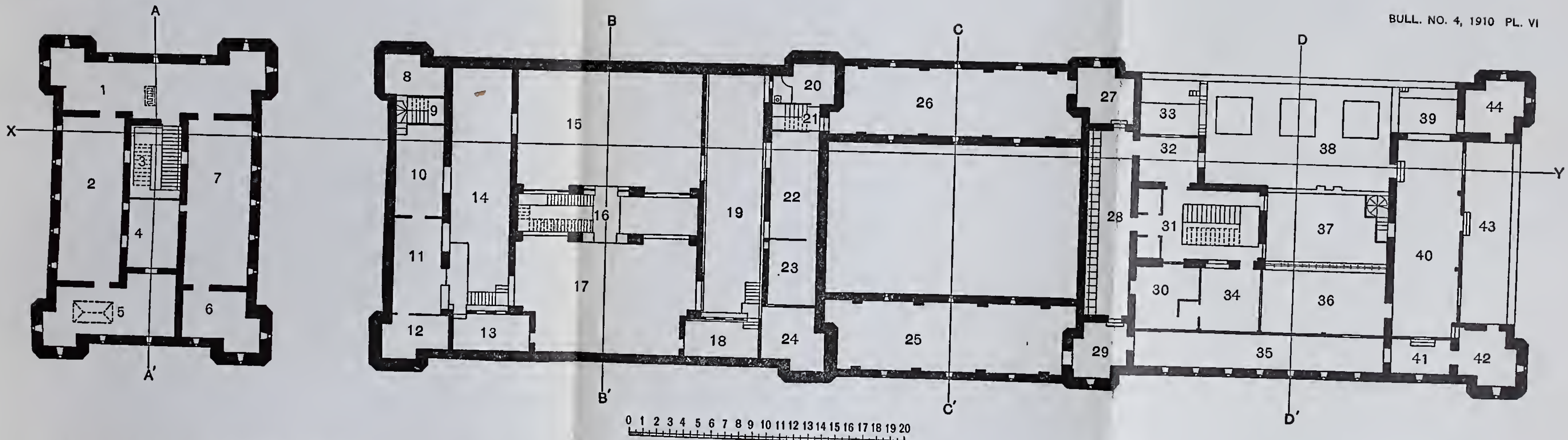
The eastern wing contains the rooms (47, 48) of the vice-director (in 1909), Dr. Reinhard Dohrn, two zoological laboratories (50, 51), and the laboratories, workrooms, and offices (Doctors Burian and Bauer) of the physiological department (52–68.)

The third floor (Pl. V, *A*) is largely given over to investigators' rooms. In the western block there are eight zoological laboratories (1, 5–8, 10, 11, and 13), the artists' rooms (2, 3), and Professor Giesbrecht's office and laboratory (14, 15). In the western wing of the main block are the reagent storeroom (18), the rooms (16, 20) in which the zoological reference collection is being installed (the former physiological laboratory), Doctor Gast's office (19), Professor Eisig's rooms (26, 27), and the former chemical laboratories (21, 23) and loggia (28) extend from the floor below into this story.

On the north side of the court in the middle section of the main block is a general zoological laboratory (31) with tables for six workers, and on the south side three separate zoological laboratories (33–35). The whole of this floor in the eastern block, comprising twenty rooms (36–55), is given over to the laboratories, storerooms, and offices (Doctor Henze) of the department of physiological chemistry.

The fourth floor (Pl. VI, and Pl. IV, *B* to *E*) has only skylight or concealed mansard lighting and contains mainly numerous small storerooms, the tank rooms (4, 12, 26) for high-level tanks, an overflow zoological laboratory (15) with six tables, the rooms formerly used as library (17), chemical (18, 20) and physiological laboratories (10, 11, 13), a splendidly equipped photographic atelier and dark room (30, 34, 36), and shower bath and dressing room.

The aquarium at Naples is justly famous for the variety and beauty of the animal life exhibited therein and for the perfection with which it is maintained. Though small in comparison with the New York Aquarium and certain others, it is exceptionally fine in the quality of its exhibits. The invertebrates are represented to an unusual extent. Noteworthy among the exhibits maintained is the superb tank of echinoderms (Pl. VIII, *B*), the exhibit of pelagic cœlenterates



FOURTH-FLOOR PLANS, NAPLES STATION.

1, 2, 5, 6, 7, 22, 25, 27, 28, 29, 35, 40, 41, 42, Storerooms. 3, Stair. 4, Tank room. 8. Servant's room. 9, Stair. 10, 11, Former physiological laboratory. 12, Tanks. 13, Former physiological laboratory. 14, Upper part of room 20 in Plate V, *A*. 15, Overflow zoological laboratory, 6 tables. 16, Light well. 17, Former library (now library storeroom). 18, Former chemical room. 19, Upper part of room 24 in Plate V, *A*. 20, Former chemical room. 21, Stair. 23, Dark room for photography. 24, Upper part of room 26 in Plate V, *A*. 26, Tank room, 25 tons capacity. 30, Dark room for station staff. 31, Stair. 32, Water still. 33, Open roof. 34, Photographic atelier. 36, Photographic atelier. 36-39, Open roof. 43, Roof and shower bath. 44, Dressing room.

and mollusks, including the delicate siphonophores and Venus's girdle, the cephalopod tank with its ever restive squids, the electric ray, the gorgeous tank of tube-dwelling worms and brilliant *Cerianthus*, one specimen of which has thriven in the aquarium for about twenty-six years, and is the original from which the colored figure in the monograph in the "Fauna and flora" was taken. The exhibit of octopus and sepia and the morays protruding their snake-like bodies from broken amphora always attract attention. The display of fishes is varied and complete. A number of the fishes have been reared from larval stages. Only the local fauna of the bay is exhibited and the contents of some of the tanks vary considerably with the season. Representatives of nearly 200 different genera are usually on exhibition.

The exhibition aquarium room (17, Pl. III, *A*, and Pl. IV, *C*) is of grotto construction, lighted and ventilated only by a few high circular windows opening into the attendants' corridors above the tanks. It is surrounded on three sides with a bank of exhibition tanks, 3 m. wide (front to rear), 1.5 m. deep, with bottom sloping toward the front, which is 0.7 m. above the floor. Along the front of the aquarium runs a hand rail outside a shelf 35 cm. wide, and the wall below is shielded by a paling of wooden slats.

The aquaria vary in size. The largest tank (at the end) is 11 m. long. The center one on the south wall is 4.5 m. long, and there are seven from 2.25 to 2.75 m. long and nine from 1.75 to 2 m. The six aquaria along the sides of the central well are 4 m. long, 1 m. wide, and 1 m. in depth. The main walls of the aquaria are of masonry .5 m. thick and their partitions 0.20 to 0.30 m., usually with irregular facings of natural rock. The floor is an arch of masonry 0.6 to 1 m. in thickness.

The fronts of the aquaria are broken up by pillars of iron or masonry into panes of less than 1 m. in width. The plate-glass fronts used measure 0.9 by 1.9 m. and 25 mm. thick, 0.75 by 1.50 m. and 22 mm. thick, and 0.75 by 1.20 m. and 20 mm. thick. The plate glass rests against frames of cast iron (half pillars 15 and 10 cm. diameter) on masonry, with an intervening strip of pure gum rubber about 2.5 cm. wide and 3 to 4 mm. thick, and at the bottom the rubber strip is bent beneath the glass to form a cushion. In earlier years an aquarium cement of whiting (1 part) and red lead (1 part) hammered into a soft putty with boiled linseed oil was used beneath and about the edges of the glass, but of late years the rubber alone is used with excellent success and little leakage or breakage. The glass is held in place at first by wooden props, but later by the pressure of the water alone. The rubber is sometimes used in connection with the cement, the edges of the glass being covered with the latter. The rubber strips are ordered from the factory with the

lower angles joined, forming single U-shaped pieces to fit the glass used.

The low-level reservoirs and storage tanks (18, 23, 25, 35, 37, 40, 43, 46, Pl. III, *A*) are of masonry, with walls 0.5 to 1.25 m. thick, faced with cement. The high-level reservoirs in the older parts of the building are small, rectangular wooden tanks with lead lining. The large high-level tanks in the new addition (26, Pl. VI) are also of wood planking 5 cm. thick, with lining of sheet lead 1.5 mm. thick, with burned lead seams and joints. The tanks are 1.08 m. high, 3.4 wide, and 3.83, 3.9, 3.9, and 2.76 m. long, respectively, are raised 25 cm. from the floor, and are tied together across the top and bottom with iron bars. They have a capacity of 19.56 cu. m. of water, about 25 tons.

In the individual laboratories there are aquaria of various types, several of which are shown in Plates VII and VIII. They are generally movable, though some are fixed to walls or have cement floor tanks. They are of one, two, or three stories, usually rectangular, though some have one sloping side. The upper aquaria are usually 30 to 45 cm. deep and 40 to 100 cm. wide, and the frames are made in units of approximately 1 m. in length, two units being often combined (Pl. VII, *B*) in a single aquarium. The stand which carries them is made of T-iron (5 by 5 cm. and 7 mm. thick) and the frame of the aquarium proper of L-iron (3.5 by 3.5 cm. and 5 mm. thick) and bar-iron (40 by 5 mm.) heavily painted with red lead. The bottoms of the aquaria are of marble and the sides of plate glass 10 mm. thick. The form and dimensions vary with the size of the room and purpose to which they are put. The upper tank is usually of glass and metal and the floor tank of wood with lead lining, or cement, with walls 10 cm. thick. A shelf below the level of the bottom of the glass aquaria for small glass vessels inclined inward to drain into the floor tank is usually attached to one or both sides of the stand. Small square aquaria (0.33 by 0.33 by 0.12 deep) in wooden frames are extensively used, and wooden racks across the floor tanks are used to support them.

The large movable aquaria in the physiological laboratory (Pl. VII, *A*) are carried on well-braced wooden horses, with a wooden tray below the tank to catch and carry away any drip or overflow.

The principal pumping plant of the station is located beneath the western court and consists of a 3.8 horsepower Siemens electric motor with a 3-horsepower steam engine for emergency use and a battery of 5 Garvens iron piston pumps. In the new addition there is a second motor of 2.7 horsepower connected with a Jaeger rotary iron pump.

The water is drawn through a cast-iron sea pipe about 140 m. in length, passing out to the sea through the city sewer. It is 50 mm. in

A. MOVABLE AQUARIA IN IRON FRAME ON WOODEN STANDARDS, WITH DRIP TRAY

B. TWO-STORY AQUARIUM WITH UPPER TANK WITH IRON FRAME AND WOODEN SHELF AND CEMENT FLOOR TANK.

TYPES OF AQUARIA IN NAPLES STATION.

diameter, and was specially enameled to order on the inside and has remained in good condition since the construction of the first building. Water is pumped usually at night and from the surface and a rubber hose 50 mm. in diameter and 45 m. in length is attached to the sea pipe and carried out from shore.

After pumping, the water is allowed to stand and undergo sedimentation in one of the three reservoirs (18, 25, 23, Pl. III, *A*) for a week before using. It is thus largely freed from bacteria. It is then pumped to the high-level reservoir on the third floor at an elevation of nearly 11 m. above the surface of the aquaria. The aquaria are connected, the overflow passing from one to the other through perforated lead plates on the top of the partitions, and is drawn off at the top of the last member of the series, returning thence to a low-level reservoir to reenter the circuit. Generally the pumps feed the exhibition aquaria directly, without use of the high-level reservoir, and in winter no pumping is done at night and only in alternating two-hour intervals during the day. The amount of water circulated daily through the aquaria is at a maximum 63 cu. m. daily in summer and 31 in winter. In the eastern plant, which supplies the physiological and chemical departments, the large storage tanks in the basement where animals for experimental purposes are kept, and the many laboratories in the eastern and middle sections of the main block, the amount pumped is about 25 tons daily.

The system of circulation is thus an entirely closed one. Leakage, waste from certain aquaria, etc., gradually deplete the water in circulation. No fresh water is added to make good the small amount lost by evaporation, the increased salinity not reaching a deleterious contamination. When the amount in the reservoirs is reduced to 250 tons or less, which happens at intervals of two to four weeks, a new supply (total amount 600 tons) is pumped into the sedimentation tank.

The laboratories in the western block are supplied with water from the aquarium reservoirs, which is first passed through the filters located in the basement. These filters were established to provide water for use in developmental mechanics and other experimental lines, but have not proven wholly satisfactory. They are wooden boxes 1.1 by 1.1 by 1 m. filled with rock, pebbles, and sand of increasing fineness from bottom upward to a depth of 0.5 m.

The piping of the aquarium circulation is of hard rubber, consisting of a vertical pipe from pump of 65 mm., horizontal main of 165 mm., and laterals to the large aquaria of 50 mm. and to the central group of 27 mm. (inside diameter). The terminals are short vertical pipes of various diameters, with orifices in a removable cap of 6 and 18 mm. The aquaria are all fed by overhead spray for aeration, discharged at an elevation of 0 to 10 cm., depending upon

the amount of discharge, distance from head, and size and contents of aquaria. No other means of aeration are used in the exhibition tanks. The aquaria in the laboratories are generally aerated on the same principle, through finely pointed glass pipettes attached by rubber tubes to the terminal cocks.

The piping of the rest of the building for sea water is entirely of soft lead. From the rotary pump a vertical pipe of 65 mm. diameter (sea pipe 50 mm.) ascends to the high level tanks from which passes a descending main of 45 mm. with mains on each floor of 30 mm. and laterals to individual rooms of 14 mm. (inside measurement). All pipes are marked with arrows showing direction of flow, whose color distinguishes gas, fresh and salt water contents. Valves and cocks in this system are of hard rubber fitted to the lead pipes by their flanges against the battered-out ends of the lead pipe reenforced by an iron flange. Rubber packing is used between the flanges.

A special type of hard lead valve to regulate water flow passing in one direction only is made in the shops of the station. It is less expensive than the large rubber valves required for the mains and less liable to breakage. As shown in figure 1 it consists of a U loop in a lead tube in one arm of which a wooden plunger with terminal rubber disk may be thrust in or out to regulate the flow of water. No ill effects can be traced to the use of this limited amount of hard lead in the extensive circulating system.

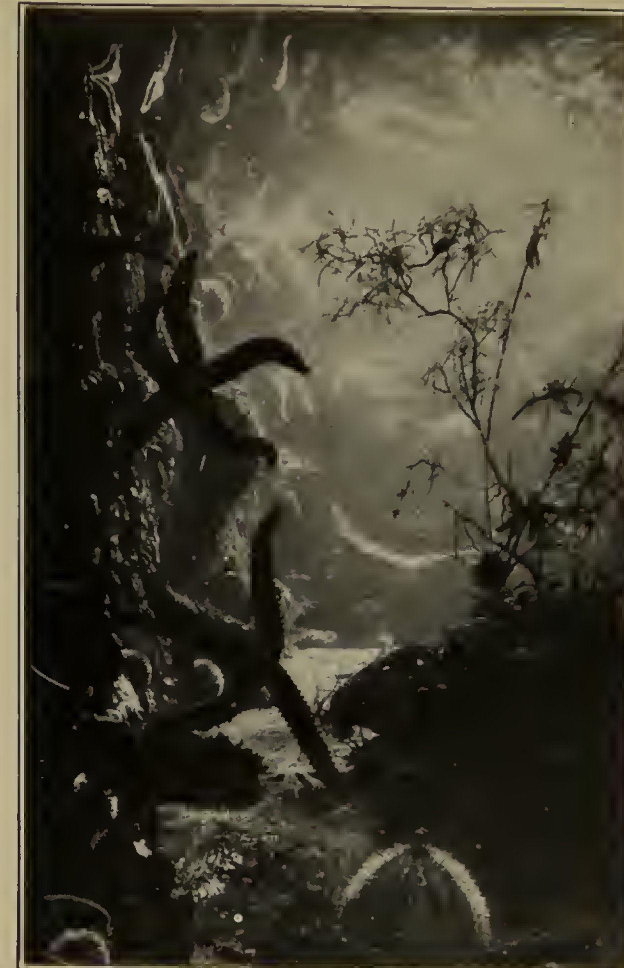
The outflow of one aquarium in the new section of the building is passed through a Bunsen air pump to a closed cement receiver in the basement, and the compressed air thus collected is piped in small lead piping, such as is used in acetylene plants, to some of the investigators' laboratories in the new section of the building.

The building is supplied throughout with fresh and salt water, gas and electric lights, and in part with compressed air. It is heated in the western block by stoves; in the rest of the building by a steam-heating plant.

The equipment of the individual investigator's rooms for botanical and zoological work is very simple. The rooms themselves vary in size; rooms for single investigators have 13 to 21 sq. m. area, while for two investigators 18 to 33 sq. m. are allotted. The equipment of the rooms, in addition to the aquaria previously described, includes a sink with fresh and salt water supply, and one or more laboratory desks, 85 by 175 cm. and 78 cm. in height, provided with two banks of drawers and two slides. A paraffin oven and gas regulator is also supplied. The station also possesses a few microtomes, which may be supplied by special arrangement, but it does not undertake to furnish them regularly to investigators.

The equipment for the work in physiological chemistry and physiology is remarkably complete and modern. The chemical laborato-

A. THREE-STORY AQUARIUM IN BOTANICAL LABORATORY WITH IRON FRAME SHELF, AND WOODEN FLOOR TANK.



B. TWO-STORY AQUARIUM OF SIMILAR TYPE, WITH WOODEN FLOOR TANK.

TYPES OF AQUARIA IN NAPLES STATION.

ries (Pl. V, *A*, rooms 36–55) contain a room (49) equipped for all sorts of general chemical work and several (40, 45, 47, 50) for special work, a laboratory (46) for physical chemistry, with apparatus for testing freezing point (Beckmann und Friedenthal), conductivity, viscosity, etc., a well-equipped balance room (41), a room (45) for culture chambers, a gas-analysis laboratory (51) with large mercury

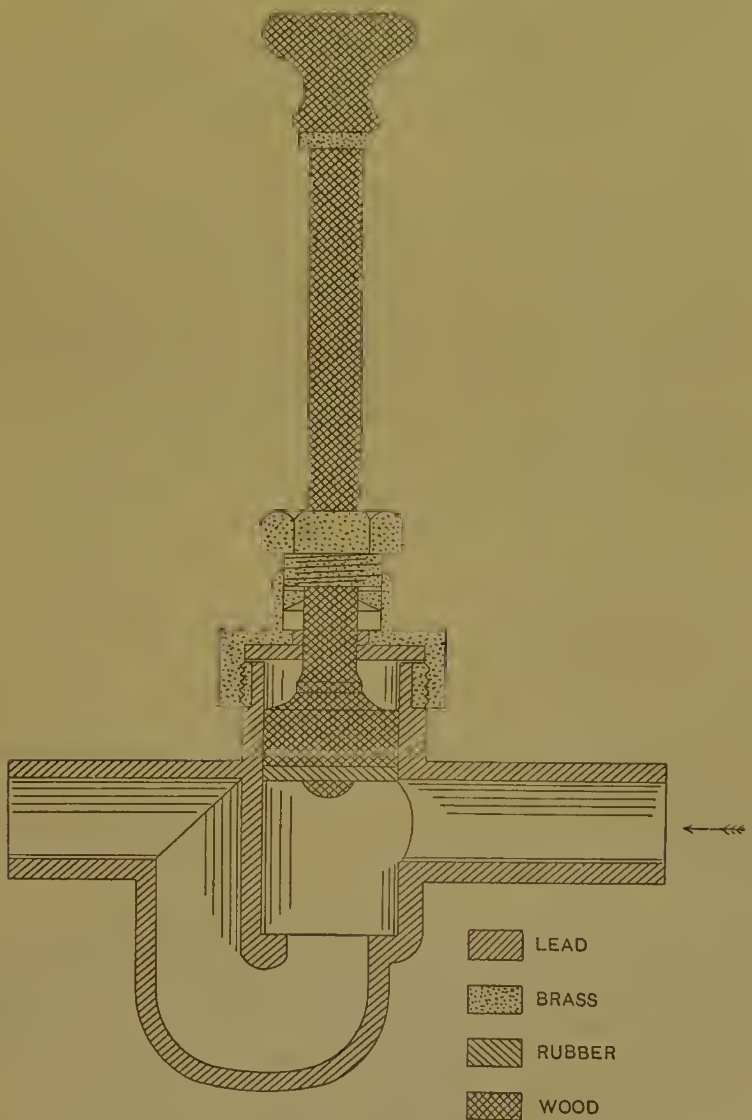


Fig. 1.—Hard lead cut-off valve as used in large lead pipes in Naples circulating system.

pump (Pflüger), a mercury pump (Bohr) for blood gases, gas burettes (Hempel), a eudiometer, Pettersson's and Haldanes apparatus, and other equipment for gas analysis in sea water, a laboratory for nitrogen determination (Kjeldahl), one for organic analysis and one equipped with thermostats, stirring apparatus, agitators, electromotors, and apparatus for research in metabolism, and a dark room for spectroscopic and polarization apparatus.

The physiological department has among its more important features the following apparatus: In the dark rooms (Pl. III, *A*, rooms 34, 35, 36) on the first floor is equipment for work in electro-physiology, including a Thomson's and a Hermann-Wiedemann's galvanometer, both with suspension after Julius, a small and a large string galvanometer (Einthoven) after Edelmann, with equipment for photographic registration.

For the graphic registration of motion a room (Pl. IV, *A*, 60) is equipped with an Englemann's pantokymographion, a Straub's electromotor kymographion, and a Hering's kymographion with electric power.

The apparatus available for use in the different physiological investigators' laboratories includes various kymographs, writing levers, electro-magnetic signals, a Jacquet's clock, tuning forks, accumulators, induction apparatus, platinum electrodes, nonpolarizable electrodes, keyboards, switches, metronomes, tuning-fork interrupter, Abblender, resistance coils, double-stringed rheochord, registering telephone, apparatus for the determination of freezing point, equipment for the determination of the electric conductivity of solutions, spectrophotometer, microspectrophotometer, Röntgen apparatus, heliostat, arc lamps, electromotors, hand and turbine centrifuges, photographic apparatus, etc.

The library of the Naples station is one of its choicest treasures. It contains over 13,000 bound volumes, among which are about 25,000 separate articles or reprints bound up in volumes of related subjects. Over 250 periodicals are currently received and the library possesses in addition about 100 others which have lapsed or been discontinued. It contains practically all of the important literature of modern zoological research and a large number of botanical and physiological periodicals and special literature pertaining to work in those lines at a marine laboratory.

The widespread custom among biologists of sending reprints of their articles to Doctor Dohrn or to the library of the station has immensely enhanced its usefulness and completeness and deserves to be even more widely followed. Each investigator is allowed to withdraw for use in his laboratory not more than 24 bound volumes.

The completeness of the library and the freedom of access to the shelves and to current literature granted to all investigators render the Naples station exceptionally attractive among the biological institutions of the world for manuscript work where access to the literature is essential. An up-to-date card catalogue and a simple system of shelving the books greatly facilitate the independent utilization of the library.

The field equipment of the Naples station consists of the small steamer *Johannes Müller*, the gift of the Berlin Academy of Sciences,

a wooden boat 17 m. long, with beam of 3 m., draft of 1.5 m., engine of perhaps 10 horsepower, and a small steam winch for dredging. There is also the *Frank Balfour*, an open boat of 9 m. length, 1.75 m. beam, draft of 0.9 m., an engine of about 5 horsepower, and a flotilla of small boats used by the fishermen and collectors.

The station depends more upon the skill and experience of its collectors and the richness and accessibility of its fauna than upon an elaborate field outfit for collecting. It has, however, all the necessary dredges, trawls, and fishing traps, gear and tackle of the Neapolitan fisherman, so that its supply of shore and bottom material is never failing. The outfit for pelagic work inherited in part from the Krupp expeditions includes tow nets of silk and stramine, nets of the Hensen and Apstein models, the Apstein, Giesbrecht and Chun-Petersen closing nets, and a large closing net of new model made at the Krupp works.

The station possesses a scaphander for exploration of the shore and bottom and submarine grottoes.

The environmental conditions about the Bay of Naples are exceedingly varied and form the basis for the great variety of life available in so small an area. Essentially volcanic in origin, the shores present a great variety of materials and configuration, basalt and tufa, sandy beaches, mud flats, caves and grottoes, and submerged quays, walls, and ruins of the Roman civilization.

The Bay of Naples itself presents an exceedingly uneven bottom deepening to 200 m. at a distance of 12 km., and 500 at 24 km., while the south slope of the isle of Capri rises quite abruptly from depths of 1,000 m. and the central basin of the Tyrrhenian Sea exceeds 3,000 m. in depth.

Surface temperatures in summer rise to 26°–27.8° C. in August and fall to 13.2°–14° in January, rarely after strong north winds to 10.5° near shore. Below 400 m. the temperature is constant at 13°. The specific gravity is slightly above that of oceanic waters. No systematic hydrographic work has been undertaken by the Naples station.

The waters of the Bay of Naples receive the sewage of a great city and are more or less contaminated with bacteria. The ill effects of this are obviated at the station to a large extent by prolonged sedimentation of the water and by filtration of that used in the morphological and experimental laboratories. The purification is assisted by the higher temperatures of a southern latitude. A small supplementary laboratory has been erected on Ischia for the use of the director and staff of the station, where by special arrangement work requiring water of exceptional purity may be undertaken.

The fauna available for reseach at Naples may be determined in part in the early work of Carus, "Prodromus Faunæ Mediterraneæ," and in the intensive monographs of the "Fauna and flora." It is

well represented in the sale lists of species furnished by the biological supply department. There are about 1,000 species in this list, including 37 sponges, 108 cœlenterates, 60 echinoderms, 145 vermes, and 198 fishes. Amphioxus, Balanoglossus, and tunicates of great variety are obtainable in abundance, a list unparalleled among the biological stations of the world for its wealth and variety. Further information regarding the material available and the seasons at which it occurs is always to be had from the authorities of the station by correspondence. Extensive accounts of the seasonal occurrence and breeding seasons of animals of the local fauna will be found in the papers of Signor Lo Bianco (1888, 1898, 1906), the last indicating the results of the eruption of Vesuvius of 1906. The algæ are treated in the paper of Berthold (1882).

Literature: Anson (1906), Bachmann (1905), Baglioni (1907), Berthold (1882), Bottazzi (1906), Burnside (1904), Caullery (1906), Dean (1894), Dohrn (1871, 1871a, 1872, 1872a, 1872b, 1872c, 1872d, 1873, 1874, 1874a, 1875, 1876, 1876a, 1877, 1878, 1879, 1881, 1881a, 1882, 1885, 1891, 1892, 1893, 1893a, 1897, 1897a), Eisig (1875), Emery (1883), Francotte (1907), Giercke (1884), Giesbrecht (1907), Gregory (1903), Hensen (1876), Houssay (1893), Leon (1894), Lo Bianco (1888, 1890, 1898, 1899, 1901, 1903, 1903a, 1904, 1906), MacLeod (1882), Mazzarelli (1908), Meek (1897), Morgan (1896), Nansen (1887), Noll (1875), Sand (1897), Schmidtlein (1879), Swingle (1897), Todaro (1897), Van den Broeck (1882), Vogt (1884), Went (1889), Ziegler (1899).

LIMNOLOGICAL STATION OF BOLSENA.

Director, Prof. Luigi Palazzo, Officio Centrale di Meteorologia e di Geodinamica al Collègio Romano. Via del Caravita N. 7, Roma.

Biologist, Prof. Decio Vinciguerra, Zoological Laboratory, University of Rome.

Following the example of the lake surveys in Hungary and elsewhere the Italian Geographical Society in 1901 established a commission, consisting of Messrs. Novarese, Sella, Vinciguerra, and Palazzo, to organize a survey of some Italian lake. The commission selected for the purpose the Lago di Bolsena, lying 80 km. northwest of Rome. The field-station laboratory is located in a house on the lake shore about one-half km. from the little harbor of Bolsena.

The station is at present engaged mainly in limnological work and is equipped with meteorological instruments, the Sarasin limnograph and other instruments for hydrographical and physical investigations upon the lake. There is also an equipment for pelagic and bottom collecting and a small laboratory for biological work.

It is purely a research enterprise without immediate affiliations to educational or economic interests.

Literature: Palazzo (1904, 1905).

STATION OF BIOLOGY AND OF APPLIED HYDROBIOLOGY OF MILAN.

Director, Prof. F. Supino, Stazione de Biologia e Bioidrologia Applicata, Acquario, Via Gadio al Pares, Milano.

Telegraph address, Acquario, Milano.

The International Exposition at Milan in 1906 had, as one of its most attractive features, a handsomely installed and admirably equipped marine and fresh-water aquarium, erected and furnished under the supervision of the Berlin Aquarium Company. At the close of the exposition the institution passed to the city, and was placed under the direction of Dr. G. Mazzarelli, who was later succeeded by Prof. F. Supino, the present director.

The institution consists of a fresh-water and marine aquarium, open to the public upon the payment of a small fee (25 centimes), and a hydrobiological institute, in which short popular courses of instruction in fish culture and hydrobiology are offered from time to time.

The building is extensive, thoroughly modern, and well equipped. The aquarium is located on the ground floor and contains 30 large salt-water tanks, 29 large fresh-water tanks, and, in addition, a large reptile and seal tank. The aquaria are of concrete, the piping of lead, and fittings of hard rubber after the manner of the station at Rovigno.

In the upper story are the offices, laboratories, and library. Here are found a large roomy laboratory equipped with desks for microscopical work, an assistant's laboratory, a well-equipped bacteriological and a chemical laboratory, a culture room with hatching troughs, and many fixed and movable aquaria with running water.

There are 7 research tables attached to the station, of which 3 are provided gratuitously by the municipality of Milan, to which application should be made for their use. To the remaining 4 an annual charge of 500 lires is attached. Application for these should be made to the director. Preference is given to applicants presented by a minister or administrative officer. Students are supplied with an aquarium with running water, and, by special arrangement, with a salt-water aquarium. Glassware, the ordinary reagents and stains, use of paraffin oven and microtome, alcohol to the amount of 1 kilo per month, and expensive reagents in limited quantities by special arrangement are provided by the station. Students are allowed to use the instrumental equipment of the station, but are expected to provide their own microscopes. Neither living nor preserved material is furnished, but students are assisted in obtaining supplies as far as possible. Admission to the aquarium and the use of the library are also granted.

Literature: Supino (1909).

BIOLOGICAL STATION OF THE UNIVERSITY OF CAGLIARI, CAGLIARI, SARDINIA.

Director, Prof. E. Giglio-Tos, professor of zoology and comparative anatomy, Royal University, Cagliari, Sardinia, Italy.

This station was founded in connection with the Royal University at Cagliari in 1909 as a result of the efforts of the director. The building, completed at the close of the year, is a simple masonry structure (14 by 31 m.) with laboratories, library, etc., a large aquarium (1 by 10 m.), and a modern equipment. The station has also an automobile boat 11.5 m. in length.

CHAPTER III.

FRANCE AND MONACO.

INTRODUCTION.

With over 500 miles of coast line bordering the whole length of the great tidal funnel of the English Channel, an equal extent fronting upon the Atlantic, and a Riviera upon the Mediterranean of incomparable beauty and attractiveness, France offers a field for the development and differentiation of marine biological work unequaled among European states. She has also large maritime interests and fisheries, both local and on the distant shores of Newfoundland and Senegal, of great and growing extent. The scientific work of the French fisheries bureau has not been developed on an independent footing, but has been attached to or associated with existing biological stations and members of the biological faculties of the universities. Add to these factors the highly centralized national system of education, with its practically coequal subdivisions, and finally and principally, the large share which men of scientific interests and training have had in shaping and developing educational policies and practice, and we have the potent influences which have led to the establishment of no less than twenty-six marine or fresh-water biological stations in France.

General public interest and liberal private munificence have also contributed very largely and in most cases made possible the building and equipment of the stations. This is true not only of the imposing Museum of Oceanography, now being built upon the cliffs at Monaco by the Prince of that little realm, with its unrivaled collections and exhibits and superb equipment, but also of its diminutive neighbor at Beaulieu, the striking Moorish villa at Tamaris, the commodious laboratory at Cette, the plain but amply equipped and efficient station at Banyuls-sur-Mer, the pride of the local community at Arcachon—with its annex at Guethary—the rapidly expanding modern station at Roscoff, the new station at Portel, the quaint building at Wimereux, and the extensive plant of the fresh-water station at Toulouse.

At some places, as at Cette and Marseille, the local authorities have also shared in the expense of foundation, and at a few places, as at Nice and St. Vaast-de-la-Hougue, hospitals erected by the state for emergency purposes have been utilized as station buildings. The

state is also a large contributor to the annual budgets of the stations, though the sums granted are inadequate to support so many stations in the proper discharge of their functions.

A factor which has had great influence in the establishment of this large number of stations on the coasts of France has been the idea that a necessary and invaluable part of the instruction in the science of zoology and, to a less extent, in physiology and botany, can be given only at the sea shore in direct contact with the life of the sea in its native environment. The more intimate association of teacher and pupil which exists under these circumstances also enhances the value of the instruction thus given. The two functions of instruction and research are combined in most of the French stations, but the primary, or at least the impelling function of a number of them, as at Marseille, Cette, Luc-sur-Mer, Portel, and Wimereux, is instruction and it is an essential part of the programmes of the stations at Villefranche, Banyuls, Roscoff, Boulogne, Grenoble, and Toulouse.

The stations preeminently equipped for research and making it the sole or primary part of their programmes are those at Roscoff, Banyuls, Monaco, St. Vaast-de-la-Hougue, Villefranche, and Concarneau. The stations at Beaulieu, Tamaris, and Arcachon give no regular instruction and are used mainly for research by their own staffs. Fisheries investigations are regularly and formally carried on at Banyuls, Concarneau, Roscoff, and St. Vaast, and constitute the main programme of the stations at Boulogne, Grenoble, Toulouse, Besse, and Bordeaux.

The hospitality of the French stations is notable. They are, with the exception of Roscoff and Tamaris, open without charge to all comers, without regard to sex or nationality, who are competent to use their facilities. The superb equipment of the new station at Monaco, French in spirit, though politically independent, has been promptly utilized by German, Polish, and Russian investigators. France gives hospitality to the station at Villefranche, under Russian management and support, and largely patronized not only by Russians and French students but also by Swiss and Germans. Her stations elsewhere, especially along the channel, are largely patronized by students and investigators from Russia, Belgium, Switzerland, Scandinavia, and an increasing number of English and Americans. In addition to opening their doors to all, the French stations generally maintain a free biological supply service, furnishing fresh and preserved material to investigators and institutions for instruction and research. The service which France by reason of her strategic position is thus rendering to the cause of the biological sciences and marine research is both effective and far-reaching.

France enjoys the unique distinction of having had the first marine biological station in the world, founded at Concarneau in 1859. This

was followed in 1867 by that at Arcachon, while, in the next dozen years, following in the general wave of advance in biology of that period, led by the untiring efforts of the far-sighted Lacaze-Duthiers, and stimulated in part by the example of Naples, stations followed in rapid succession at Roscoff (1872), Wimereux (1873), Luc-sur-Mer (1874), Marseille (1876), by the private station of Fol and Barrois at Nice, by the French station at Villefranche (1880), succeeded in 1882 by the Russian, Cette (1881), Havre (1882), Banyuls (1883), and Boulogne (1884). Special or institutional interests resulted in the establishment of the stations at Tamaris (1891), St. Vaast (1892), and Beaulieu (1901), and the industrial and economic interests of the fisheries led to the institution of the station at Les Sables d'Olonne and to the fresh-water stations at Grenoble (1901), Toulouse (1902), Bordeaux, and Besse (1893).

MONACO.

INSTITUTE OF OCEANOGRAPHY.

Council of administration:

President, S. A. S. Albert I^er de Monaco. Members, Prof. P. Regnard, director of the National Institute of Agronomy; M. Cailletet, member of the Institut de France; Professor Darboux, secretary of the Academy of Sciences; M. G. Kohn, secretary of the Sociëté Industriélles, and M. L. Mayer, private counsel of the Prince of Monaco.

Committee of perfection:

President, S. A. S. Prince Albert I^er. Members, Messrs. A. Agassiz (Cambridge), A. Berget (Paris), Prince Roland Bonaparte, E. L. Bouvier (Paris), W. S. Bruce (Edinburgh), J. Y. Buchanan (Cambridge), F. A. Chaves (Azores), C. Chun (Leipzig), Y. Delage (Paris), E. von Drygalski (Berlin), Fabre-Domergue (Paris), F. A. Forel (Morges), V. Hensen (Kiel), H. Hergesell (Strassburg), L. Joubin (Paris), O. Krümmel (Kiel), Sir John Murray (Edinburgh), F. Nansen (Christiania), E. Perrier (Paris), P. Portier (Paris), J. Richard (Monaco), A. L. Supan (Gotha), J. Thoulet (Nancy).

This institute, founded by S. A. S. Albert I^er, Prince of Monaco, includes two establishments, the Oceanographical Institute now in construction at Paris, and the Oceanographical Museum just completed at Monaco. The same administrative council and advisory committee have charge of both the institute at Paris and the museum at Monaco, but the staffs of the two establishments are separate and independent.

OCEANOGRAPHICAL INSTITUTE, PARIS.

The institute at Paris, designed for instruction and research, conducts courses of public lectures on subjects relating to oceanography and has at present a small faculty consisting of a professor and préparateur of "Océanographie physique" (Dr. A. Berget and M. Klein), of "Océanographie biologique" (Dr. L. Joubin and Dr. L. Germain), and of "Physiologie des êtres marins" (Dr. P. Portier and Mme.

Gatin-Gruzewska). The researches of the institute at Paris are published in the "Bulletin de l'Institut Océanographique" issued at Monaco.

OCEANOGRAPHICAL MUSEUM OF MONACO.

Founder, S. A. S. Albert I[er] de Monaco.

Director, Dr. Jules Richard, Musée Océanographique, Monaco, Principauté de Monaco.

Secretary and chemist, Dr. Mieczyslaw Oxner.

Assistant and librarian, M. lic. Louis Sirvent.

Taxidermist, M. Grimm.

Employees: One photographer and amanuensis, three laboratory servants, one machinist, one fireman, one captain, and two fishermen.

Telegraph address: Musée, Monaco.

With the assistance of the Emperor of Germany, the cornerstone of the Oceanographical Museum of Monaco was laid on April 25, 1899. The building was completed toward the close of 1909 and was formally dedicated to its uses the following year in the presence of a representative assembly of scientists from all parts of the world. The institution, magnificently furnished, amply endowed, and dedicated to this field of pure research, is the gift of S. A. S. Albert I[er], Prince of Monaco, himself a contributor in a large way to the advancement of science in this field for nearly three decades.

The museum as originally planned was designed merely to hold the rapidly accumulating collections made by the Prince in his numerous cruises in the *Hirondelle* and later in the *Princesse Alice I*, and *Princesse Alice II*. The project grew, however, and as years passed, finally took the form of a general collection of all marine life and an exhibition of the results of oceanographic research and the methods and apparatus employed in its prosecution. In the same building provision is also made for laboratory researches by competent investigators in the fields included in the scope of the museum.

Connected with the scientific expeditions of the Prince in 1888 and continuously since 1891 has been Dr. Jules Richard, the zoologist and oceanographer. As chief of the zoological laboratory on the *Princesse Alice*, scientific secretary of the Prince since 1895, and director of the museum during the years of its development and expansion, Doctor Richard has had no small part in the establishment and upbuilding of the magnificent institution which crowns the brow of the rock of Monaco.

Associated with the Prince in earlier years of his explorations and scientific enterprises, for longer or shorter times, have been Baron Jules de Guerne, Prof. Paul Regnard of the Sorbonne, Prof. G. Pouchet, Dr. J. Y. Buchanan of the *Challenger* Expedition, Prof. K. Brandt of Kiel, and Dr. W. S. Bruce of Edinburgh.

In 1907, Dr. M. Oxner assumed the manifold duties of secretary, hydrographer, and chemist, and has assisted in the rapidly expand-

ing development of the laboratories of the new museum which were first opened for use in 1901. It is greatly to be hoped, in the interests of the cause to which the museum is dedicated, that an increased scientific staff and personnel will make possible a fuller utilization of the superb facilities offered at this institution, with its ample laboratories, large collections, and fine situation.

The affairs of the museum and of the biological station connected therewith are controlled in common by the central committee at Paris, above noted, of which the Prince is chairman. Both are administered directly by the small scientific staff of three members. The entire support is the gift of the donor, who, in addition to the large sums given for running expenses and equipment, has contributed annually over 13,000 francs for the salaries of the scientific staff and 17,000 francs for the pay roll of the labor largely employed in the station features of the work, since the museum is only recently completed.

The station is open without charge to all competent investigators in biological sciences and oceanography. Application should be made in advance to the director, stating full details as to the line of investigation to be pursued, the time of arrival and departure, and a full list of apparatus and chemicals needed. The institution does not provide microscopes but furnishes free a microtome and all other necessaries for laboratory work. Investigators have the use of an ample supply of aquaria, may accompany the *Eider* on its collecting trips, have access to the library and collections, and, by special arrangement, have the use of museum material for research. There are no restrictions as to choice of subject for investigation or place and manner of publication. A half dozen furnished chambers are provided in the building for the use of visiting investigators. It is expected that a circular of information will be prepared for applicants, with full details regarding the conditions under which the laboratories may be used. The excellent facilities so freely offered at Monaco have been promptly utilized by a constantly increasing number of scientists. In 1908 more than twelve visiting investigators carried on researches in the laboratories of the museum, coming mainly from Germany, Switzerland, Russia, and Italy, and giving thus a distinctly international and cosmopolitan aspect to the clientele of the museum.

The museum, independently of the explorations of the *Princesse Alice*, has for several years conducted a programme of hydrographic and planktologic explorations at regular intervals in the neighborhood of Monaco and is preparing a topographic and faunistic map of the adjacent sea bottom. The results of this and other exploratory and faunistic work appear in the "Bulletin de l'Institut Océanographique (1905+, No. 153 in 1909).

The Musée Océanographique stands in a commanding position high upon the cliff of the great promontory of Monaco. It lies near the eastern end of the beautiful garden of Saint-Martin, not far from the end of the Monaco tramway. The picturesqueness of the location of the museum is enhanced by the fact that it is perched on the steep face of the cliff with its long façade seaward, rising to a height of 75 m. from foundations which reach almost to sea level (Pl. IX, *A*). Between the archways of the foundations the face of the natural rock remains undisturbed. The main axis runs east northeast by west southwest with the main façade to the north northwest fronting on Avenue Saint-Martin.

The building is an imposing structure architecturally, in the modern French style, the work of M. Delefortrie. It is in the form of a rectangle 100 m. in length, with a central block (20 by 20 m.) and projecting wings (15 by 40 m.). The central block projects and forms the main entrance and vestibule. As seen from the front (Pl. IX, *B*) it appears to be of but two stories, but the sloping cliff below provides for a basement and subbasement below the level of the street, so that the building has four floors with 6,300 sq. m. of floor area. The main façade is richly ornamented with architectural carvings, some of which, as for example, the globes upon the corner towers, the albatross and fishhawk above the portal, the walrus head in the main gable, and the minor details of shells and ship fittings suggest the purpose of the building. Upon either side of the main portal are allegorical bas reliefs by Dussart; upon the right, "Truth unveiling to Science the Forces of the World;" at the left, "Progress coming to the relief of Humanity." Carved upon the frieze of the building are the names of vessels of all nations which have been engaged in marine exploration, as follows: *Gazelle, Investigator, Novara, Vitiaz, Belgica, Talisman, Valdivia, Washington, Vega, Fram; Princesse Alice, Hirondelle; Pola, Blake; Challenger, Siboga, Buccaneer, Amelia, Ingolf; Albatross.* Entering the imposing portal one finds himself in the lofty vestibule whence lead the stairs to the floor above. The vestibule opens directly into the central reception hall, with high ceiling (7 m.) from which open, on the right, a large lecture hall (15 by 40 m.), and, on the left, an exhibition room of similar dimensions. The floor above is likewise wholly given over to exhibition halls, its high ceiling (11 m.) affording room for a gallery likewise containing exhibition cases. On both floors the doors are so arranged that the three halls can be thrown together in one great room (100 m. in length) at times of public gatherings, congresses, etc.

The exhibition rooms are superbly fitted up with metal cases and plate glass and are abundantly lighted by the large, well-distributed windows upon three sides of the rooms.

A. END FAÇADE.
From photograph from Doctor Richard.

B. FRONT FAÇADE.
From photograph from Doctor Richard.

MUSÉE OCÉANOGRAPHIQUE, MONACO.

The roof is double, with intervening air chamber of about 1 m. height to reduce the summer's heat. On the flat top of the building (1,500 sq. m.) is a small roof garden, and on the projecting central section at a slightly higher level is a fully equipped meteorological station. The intention is to make use of the roof (75 m. above the sea level) for the study of currents by means of buoys whose movements can be followed by telescope.

In the first basement, which extends under the whole building, are storerooms, library, publications room, collection rooms, chemical laboratory, offices of director and secretary, and five private laboratories for investigators working upon the collections or for students of oceanographic problems. These rooms can be lighted only from the seaward face and consequently have considerable depth (8.5 m.).

The second basement contains in the western wing a large atelier for the preparation of exhibits, especially for those of large size, as for example, the skeletons or models of cetaceans, seals, etc. It is equipped with a gas motor and other machinery for the mechanical parts of the work. In the recess of the cliff below this floor is a large open room in which are placed the macerating vats for the osteological preparations. One basin is large enough to receive the entire skeleton of a large cetacean.

The eastern wing of the subbasement contains the large aquarium room intended ultimately solely for culture, observation, and experimental work along scientific lines. With the present small staff occupied with the details of equipment and administration of so large an enterprise, no extensive work in these lines has been undertaken. The aquarium room is open to the public, without charge at present. In the future it is planned to erect a public aquarium above the ancient prison to the left of the museum, and devote the present rooms entirely to scientific purposes.

The aquarium room is lighted by three low, wide-arched windows (4 by 4 m.), but its illumination is increased by white walls, and a row of numerous electric lights above the tanks may also be used if necessary. From the dark-walled corridor there may be seen a bank of 9 tanks made of reinforced concrete (Pl. X), with walls 10 cm. in thickness and partitions 6.7 cm., and with inner faces covered with irregular material or artificial stones. The aquaria are 1.6, 2, 1.6, 5.2, 2.6, 2.65, 1.55, 1.45, and 1.45 m. in length, respectively, and have a height of 0.9 m. and a width at the top of 1.35 m. and at the bottom of 1 m., thus giving a slope to the rear face. The water is 0.75 m. deep. A rolling stair at the rear of the aquaria (Pl. X, *A*) serves for attendance. The openings are glazed with plate glass 23 mm. in thickness. The first plates were set in Portland cement, but later this method has been discontinued on account of breakage, and now

the glass (F) is placed on the front of the aquarium (see figs. 2 and 3) between two strips of pure Para rubber (A), the inner 10 mm. and the outer 4 mm. in thickness. The inner rubber strip rests against a heavy oak bar (B) and the outer against an iron plate (C). Projecting bolts (D) (1.8 by 30 cm.) from the concrete wall (E) pass through the oak bar (4 by 4 cm.) and iron plate (2 by 8 cm.) and bind the whole firmly against the concrete front of the aquarium. A strip of rubber (fig. 3) is also placed beneath and behind the lower edge of the glass, and, on the front, the channel is filled with aquarium cement (G) (Naples formula), with occasional sections (8 cm. long) of Portland cement, at intervals of 0.5 m., to carry the pressure, set in place after the aquarium cement is filled in. The upper edge is left entirely free in short sections or in long panes (over 2 m.), is secured by occasional iron L-pins with rubber cushions on their inner face. The aquarium cement on the lower edge is channeled to gather any leakage or drip, and the overflow from the channel is collected in a centrally located outlet (H) and passed to a lead pipe which runs below the front of the aquaria. With the rubber packing there is little or no leakage about the front of the aquaria. The tanks are 1.15 m. above the floor and are guarded by a projecting cement shelf 25 cm. wide.

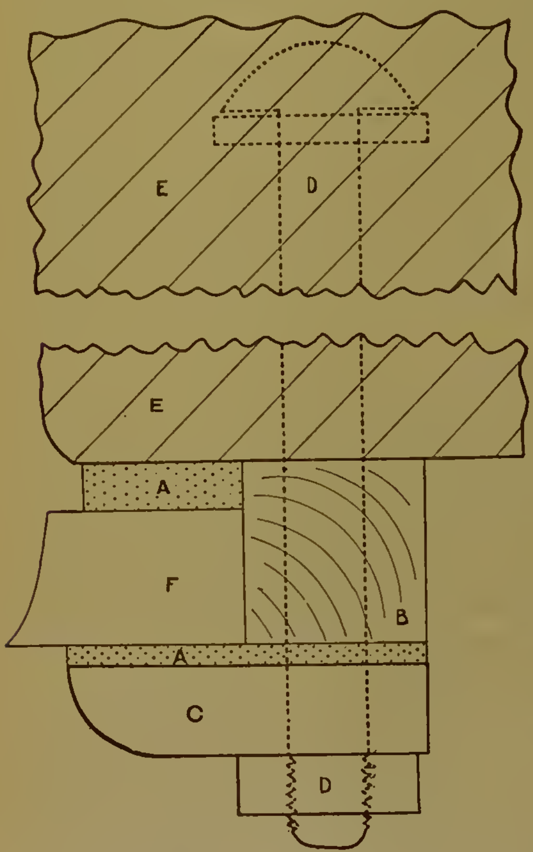
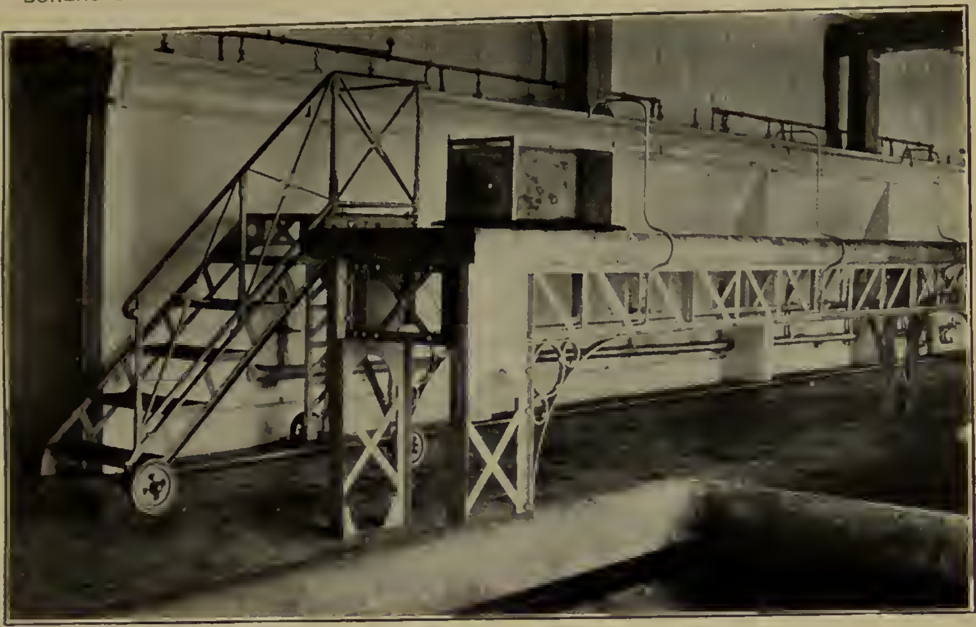


Fig. 2.—Cross section of fittings at end of glazed opening on aquarium fronts, Monaco.

There are in addition two large tanks, each 3 m. long, 2.7 m. wide, and 1.25 m. in depth with walls 20 cm. thick and with glass 1.38 by 2.65 m. and 30 mm. thick, mounted as in the other aquaria. Adjacent to these tanks there is an open floor tank (3 by 6 m. and 0.6 m. in depth) of reenforced concrete lined with white glazed tile with cement walls 10 cm. thick and side windows 0.3 by 0.7 m. (Pl. XI, *B*). It is used as a turtle tank and contains three sea turtles (*Thalassochelys caretta*) brought from the Azores, one of them in 1896. There is also a series of six simple cement tanks of rectangular form upon the floor near the windows used as culture basins (Pl. X, *B*). These are



A. REAR OF EXHIBITION AQUARIA, ROLLING STAIR FOR ATTENDANCE, AND RACK FOR EXPERIMENTAL AQUARIA.

B. THE SAME, SHOWING ALSO THE FLOOR TANKS.

AQUARIUM ROOM, MONACO.

1.1 by 2.1 m. and 0.6 m. in depth, with walls 8 cm. thick. Each has a glazed window 0.3 by 0.7 m. and lead standard for overflow of surface water.

Between these floor tanks and the rear of the large tanks is a long sink table (Pl. X, *A* and *B*) carried by a well-braced iron framework of angle iron. This table serves for many small culture and experimental aquaria. The table top is of reenforced concrete 10 cm. in thickness with rounded rim. It is 1 m. in height and slopes toward the middle, where the overflow from the aquaria upon it is collected and carried away in a lead pipe. The water supply is distributed along its length by curved arms of copper pipe lined with lead rising to a height of 60 cm. at the side of the table.

The aquarium table and laboratories are supplied with numerous small rectangular aquaria of several sizes, 125 by 40 by 60, 64 by 34 by 45, 70 by 34 by 32, 45 by 27 by 30, and 39 by 19 by 17 cm. in length, width, and height, respectively. They are made with metal (iron or brass) frames, on marble or slate bases, or with entire frame of metal and glass bottom. Plate glass of 13 and 8 mm. thickness is used for the sides. Metal parts are protected externally by aluminum varnish and internally by aquarium cement of rubber and tallow, made by saturating melted tallow with pure Para rubber. These aquaria are provided with bottom plug for wash-out and with standpipe for outflow of surface water.

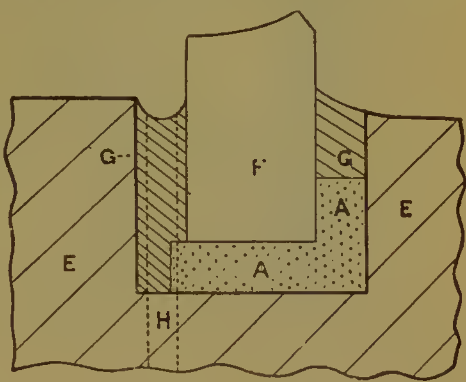


FIG. 3.—Bottom edge glass on aquarium fronts, Monaco.

The pumping plant is located in a small building concealed in the rock at the base of the cliff. There is a triplicate system, two pumps with complete piping to the high-level reservoir, and a third which is connected with the reservoir which receives the outflow from the aquaria for emergency use in case the water from the sea is not available. In the lower pump house there is a 6-horsepower electric motor connected with a 3-cylinder horizontal plunger-pump of special pattern made of phosphor bronze, and a 2-horsepower motor connected with a 3-cylinder vertical brass-lined plunger-pump of Worthington type. The water is drawn from a depth of 2 m. in lead pipes similar to the mains above. The cliff descends abruptly to a depth of 20 m. below sea level affording clear water at the immediate shore and the pipes project only several meters from the wall, ending in a perforated section. The check valves are located in a well at the shore above water level. Mains of 9 and 6 cm. (external diameter) soft lead pipe run from the two pumps to the reservoir of masonry

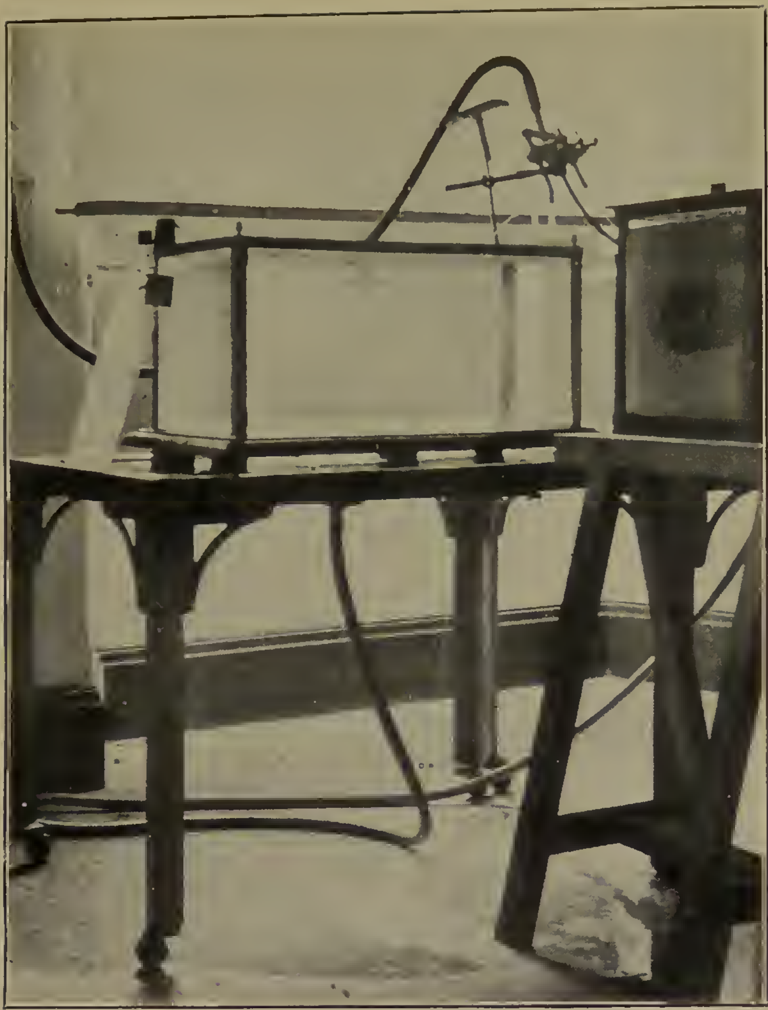
located in the northern wall of the building at an elevation of 64 m. above sea level and 13 m. above the level of the aquarium room. This reservoir has a capacity of 18 cu. m., and is filled once daily by two hours pumping with the larger pump. The lead mains are carried up the cliff in runs of angle or channel iron which afford the necessary rigidity to carry their weight.

The third pump located below the subbasement on the side of the cliff is a horizontal plunger-pump of phosphor bronze of Japy-Belfort type. It is run by a 2½-horsepower electric motor and has mains of 5 cm. lead pipe connected with a circular reservoir of reenforced concrete 5 m. in diameter and 2.5 m. high, with walls 8 cm. thick and a capacity of 50 cu. m. Water from the aquaria is received here and may be returned to the high-level reservoir if desired.

All the piping in the circulating system, originally of brass, has been changed to soft lead or brass lined with lead. The cocks and valves were of brass, but have been replaced by hard rubber. Mains are of 6 and 9 cm. diameter, laterals of 3.5 and 2.2 and terminals of 1.5 cm. Overflow pipes are of 3.5, 4.5, and 9 cm. and are provided with end and side plugs for cleaning out. The aquaria are supplied with overhead pipes discharging through glass or lead tubes carried to the bottom of the tank and are aerated by air admitted through the rubber connection joining the glass tube to the terminal cock. The outflow is carried off from the surface of the aquaria in three lead pipes set in the wall.

The field equipment of the museum includes a small steamer of 25 tons (gross), the *Eider* (Pl. XII, *A*). She is 16.5 m. in length, 3.6 m. wide, 4 m. deep, with draft aft of 1.5 m. She has a compound condensing engine of 50 horsepower, and can make 9 knots per hour. Her bunkers hold but 1,500 kilos of coal. She carries a crew of a captain, engineer, and two sailors and has four berths in the forecastle and four aft in the cabin. She is equipped with a 6-horsepower winch in the engine room amidships carrying 5,000 m. of 2 mm. galvanized steel sounding wire for hydrographical and plankton work and 3,000 fathoms of 8 mm. steel cable (not galvanized) for dredging. The breaking strain of the two are respectively 1,800 and 5,400 kilos. The boat carries a full equipment of tow nets, plankton nets, Nansen closing net, Richter reversing thermometers and Richard water bottle, as well as the usual dredges and trawls for bottom work.

The museum is only now entering upon its proper scientific functions and any account of its equipment is necessarily of a preliminary nature. There are at least five investigators' rooms available at present and tables for at least twelve persons, with possibilities of some increase in the number in the near future. The rooms are supplied with fresh and salt water, gas, electric light, and steam heat. There are large investigators' desks, tables with glazed lava tops,



A. MOVABLE AQUARIUM OF LABORATORIES.

B. TURTLE TANKS, WITH TILE LINING.

AQUARIA, MONACO.

aquarium stands (Pl. XI, A) with marble tops, on castors, with hose connections for the waste. These can be moved about into any desired light for experimental purposes.

The laboratories are provided with the common chemicals for biological, hydrographical, and physiological work and a general stock of biological and physiological glassware. There are also thermostats and paraffin baths and a Radaic microtome available for the use of investigators. Ample provision is made for all special needs of investigators when due notice is given in advance.

The chemical laboratory is equipped with Knudsen apparatus for salinity determinations as supplemented by Doctor Oxner for rapid analysis when large numbers of samples are to be examined. With the help of an assistant and these modifications of the apparatus, it is possible to determine thirty samples per hour. This laboratory is provided with water and electric motors, with ventilation hood, and large lava-topped work tables and a considerable quantity of general chemical apparatus.

The biological collections of the museum proper are displayed in rectangular containers of glass with polished fronts, and the objects are arranged upon sheets of white or colored opal glass. The collections illustrate primarily the fauna and flora of the Mediterranean and the territories in the Atlantic, especially about the Azores, the Gulf of Gascony and the Arctic Ocean explored by the ships of the Prince. The collection is not, however, limited to these fields, but in its scope includes all the fauna and flora of the sea, with special reference to that of the pelagic and abyssal areas. The exhibits are in part arranged systematically according to the relationships of the animals and in part in biological assemblages, typical of different regions or types of environment. Fully labeled anatomical preparations of many principal organisms or of special features of morphological or biological significance are also displayed. The collection is specially rich in cetaceans, cephalopods, and the life in the sea at great depths.

A most interesting and valuable feature of the exhibit is the unique collection of models, reliefs, charts, and photographs illustrative of the physics, chemistry, and geography of the sea, and of the ships and instruments employed in its investigation. The collection of oceanographic apparatus is unique in its completeness, including as it does examples or models of practically all known types from the beginning of the period of exploration to the present day.

In addition to the exhibition collection there is also a reserve collection of duplicate material and the beginning of a reference collection of carefully selected and fully named specimens for the use of students and specialists.

The library of the museum contains several thousand volumes dealing with marine biology and oceanography in the widest sense and is in receipt of a number of current periodicals. It is rich in the literature of scientific expeditions, of hydrography and of oceanography, and contains many reprints and separata arranged according to subject.

The museum at Monaco is superbly located in so far as purity of the water is concerned. The shores slope abruptly into deep water, and the promontory of Monaco juts out into the sea for several kilometers, so that the foot of the cliff upon which the building stands is washed with sea water relatively free from sewage contamination. The salinity is subject to very slight fluctuations (chlorine, 20.29 to 21.12). Surface temperatures range from 13° in February and March to 25° C. in August. Tides are slight, as elsewhere in the Mediterranean, with a maximum of 80 cm., affording little opportunity for tide pool or shore collecting. This, combined with the steep and rocky shores, reduces somewhat the opportunity for collecting the littoral fauna.

The sea bottom is varied, affording within a short distance of Monaco a wide range of environment. It slopes to a depth of 300 to 500 m. within a distance of 5 kilometers from shore. A few shallow dredging grounds are available in the neighborhood.

Researches dealing with the local environmental conditions, with the plankton and hydrographical data, and with the distribution of the local fauna are in course of publication or preparation by the staff of the museum. An account of the hydrographical conditions and plankton has been published by Nathanson (1909).

The museum at Monaco offers exceptional facilities for experimental work with living animals in aquaria, for research in hydrographical lines and on plankton problems, while its collections are exceptionally complete in material representing the pelagic and abyssal fauna. With expansion of its scientific staff commensurate with its material equipment it may easily take a leading place among institutions for oceanographic research.

THE PRINCESSE ALICE II.

The Prince of Monaco conducts each year a campaign of oceanographic research in his steam yacht, the *Princesse Alice II.* These campaigns are independent of the museum in support and management, though Doctor Richard, the director of the museum, is also "chef du laboratoire" of the vessel, and the material obtained in these campaigns enriches the collections of the museum.

The *Princesse Alice II*, the successor of the *Hirondelle*, a sailing yacht, and of the *Princesse Alice I*, was built in 1898 especially for the purposes of marine exploration, with the added comforts and

luxuries of a modern pleasure yacht. She is a steel steamer, 73.5 m. long, 10.4 beam, and a draft of 4.5 m., of 1,420 tons gross, with two masts, brigantine rigged, and with a bunker capacity of 245 tons of coal. There are double boilers and a triple-expansion condensing engine of 1,000 horsepower, giving a speed of 13 knots per hour. Her officers and crew number sixty and she has cabin provision for four scientists. A steam winch with two drums is placed forward of the deck house for maneuvering the dredging cable and other tackle. Immediately behind it are two large reels, 2 m. in diameter, driven by electric motor. The starboard reel contains 12,000 m. of dredging cable 14 mm. in diameter, composed of 72 galvanized steel wires arranged in 6 strands of 12 wires each. The cable has a breaking strain of 7,000 kgs. The reel on the port side carries the cable used in connecting the deep-sea traps or "nasses" to the floats which mark their position. This cable is 6 mm. in diameter and is composed of 42 galvanized steel wires arranged in 6 strands of 7 wires each. It is made up in lengths of 500 m. with splice (epissure) connections so that the length of cable may be adjusted to the depth to which the trap is sunk. The floats are galvanized iron buoys, supplemented by rubber air balloons when necessary and carrying a flag or light to make it possible to locate them at sea.

The traps are polyhedral frames of wood covered with mesh and contain guarded funnels for the entrance of fishes and several included traps of finer mesh for smaller crustaceans, etc. These instruments have been remarkably successful in capturing deep-sea and bottom animals in large numbers, especially those freely moving fishes and crustaceans which ordinarily escape the dredge and trawl. It has been used successfully in depths exceeding 5,000 m. and captures great quantities of fishes, etc., taking, for example 1,198 specimens of a deep-sea fish, *Simenchelys parasiticus*, at a single time, a fish not taken in trawling on the same ground.

The ship carries a very complete equipment of otter and beam trawls, drift nets, pelagic trawls, and plankton nets, closing nets of the Monaco (curtain) type and the Giesbrecht pattern as modified by Richard. The equipment for the capture of marine mammals is remarkably extensive, including harpoons, lances, and whale guns of all descriptions. The hydrographic equipment consists of a Le Blanc sounding machine carrying 12,000 meters of 2.3 mm. galvanized steel sounding cable, formed of 9 wires in 3 strands of 3 wires each. The machine is arranged so that the weight of the free wire is carried entirely by the steam winch, which is separate from the reeling drum, the speed of which is adjustable to that of the hoisting drum. Sounding cups of the Buchanan and Leger patterns, thermometers of Chabaud et Hemot and of Richter, and water buckets of Buchanan

and Richard, and bacteriological water sampler of Portier are used on the *Princesse Alice.*

A receiving laboratory is located forward, behind the cable reels on the main deck. It is provided with a large table for sorting or dissecting and serves as an instrument and tackle room, and communicates with the main laboratory below. The main laboratory is lighted by five large portholes and a skylight, and is provided with electric lights. It is furnished with fixed and swinging tables, a large sink with fresh and salt water, lockers for glassware, reagents, books, and instruments, and metal tanks for alcohol. The floor is covered with sheet lead, turned up at the edges to prevent escape of liquids. A large hold for storage is located beneath the laboratory.

The results of the explorations of the *Princesse Alice* and her predecessors appear in a finely illustrated quarto series of monographs of which No. 34 appeared in 1909.

Literature: Nathanson (109), Oxner (1908), Richard (1900, 1900a, 1908).

LABORATORY OF MARINE BIOLOGY OF BEAULIEU.

(École des Hautes-Études, Beaulieu, Alp. Marit.)

Director, Prof. A. Guieysse, Laboratoire d'Histologie, École de Médecine, Paris.
Keeper, Felix Garziglia, Beaulieu.

This little laboratory of marine biology, at Beaulieu, was founded in 1904 by the director and has been equipped and maintained at his personal expense. It is utilized by the director and his associates for their researches and is opened to competent investigators by special arrangement.

It is beautifully located at the water's edge, on the tiny fisherman's harbor, in the "Anse des Fourmis" at the base of the peninsula which separates the roadstead of Villefranche from the Golfe de St. Hospice in the suburbs of the new watering place Beaulieu.

The building is a small masonry structure of one story, located on the fishermen's quay, a few meters from the water's edge and 0.5 m. above sea level, facing the south and west. It contains two laboratories, a main room (6 by 9 m.), well lighted and provided with four work tables with tops of opaline glass (0.6 by 1.25 m.), a central table (1.1 by 2.6 m.), and a bank of five aquaria, each (0.6 m. high, 0.6 m. wide, and 0.9 m. long, with plate-glass fronts 1 cm. thick) set in iron frames. There is also a floor tank of tile and cement (1.4 by 2 m. and 0.68 m. high, with walls 8 cm. thick), with cement table for wall aquaria above. A second laboratory room, also well lighted (3.7 by 4 m.), is provided with work tables and tile-topped work bench (6 by 3 m.). There are also a dark room (1.5 by 2.5 m.) equipped for photographic work and a pump and tank room (1.7 by 2.5 m.).

A. THE "EIDER," OF THE MONACO LABORATORY.

From photograph from Doctor Richard.

B. GENERAL VIEW OF RUSSIAN ZOOLOGICAL STATION AT VILLEFRANCHE.

Photograph by Doctor Davidoff.

The laboratories are handsomely furnished and are provided with gas heaters and fresh and salt water. The equipment includes an assortment of chemicals, reagents, and glassware for biological and bacteriological work, an autoclave, thermostat, water motor, etc.

The pumping plant consists of a three-fourths-horsepower Otto gas motor and an Otto rotary iron pump, with an open circulating system of lead pipes. The mains are 5 cm. and laterals of 3 and 1 cm. external diameter. The aquaria are supplied with overhead pipes and the terminals are of rubber and glass tubing. The outlet is a vertical standpipe with surface overflow. All cocks and valves are of brass. The sea pipe is of lead, opening directly at the water's edge.

The station is provided with a small motor boat (1 by 7 m.), *La Galathée*, with 8-horsepower naphtha motor, for collecting at sea and utilizes the fishing outfit of its fisherman attendant, M. Garziglia, for fieldwork.

A number of local fishing boats make their headquarters at the quay. The immediate neighborhood affords rocky shores, with bottom of sand, gravel, and rock abounding in extensive fields of algæ. The fauna and flora are essentially similar to those at Villefranche and Monaco.

RUSSIAN ZOOLOGICAL STATION AT VILLEFRANCHE-SUR-MER.

Director, Prof. A. Korotneff, Laboratoire Russe de Zoologie, Villefranche-sur-Mer, in January–February, at Zoological Laboratory, University of Kief, Russia. The rest of the year, Villefranche.

Vice-director, Dr. M. Davidoff, resident at Villefranche.

Assistant, Th. Spitschakoff.

In addition, one preparator, two collectors, and one servant.

Telegraph address: Laboratoire Russe, Villefranche-sur-Mer.

The deep, sheltered roadstead of Villefranche-sur-Mer has long been noted as a favorite locality for the marine biologist. It is protected by high cliffs from storms, save only those directly from the south, and the water is blue, clear, and free from contamination. It was here, at the village of Villefranche, that Professor Fol, in 1880, opened, at his own expense, a marine laboratory in the then unoccupied lazaret, a large stone building on the "Darse" or inner harbor, adjacent to the old citadel. After Professor Fol's lamented loss at sea, in 1881, the laboratory was taken over by the French Government in 1882 and Prof. J. Barrois, of the University of Lille, was named as director. The epidemic of cholera, however, in that year brought the laboratory again to its original uses, and it was then proposed to erect a new building for the station.

This project was, however, dropped when the Russian Government, at the suggestion of Professor Korotneff, of the University of Kief, agreed to establish a biological station in a large building, formerly

used by the Russian naval vessels when in winter quarters at Villefranche, as coal depot and repair shop. This permission was supplemented by a grant of funds for the upkeep of the building and support of the station. Professor Korotneff became director of the new station and has since continued in that relation. In 1894 he was joined by Dr. M. Davidoff as vice-director in continuous residence at the station. Under their joint leadership the station at Villefranche has won an enviable position among the stations upon the Mediterranean not only for the richness of its pelagic fauna, but also for the courteous hospitality extended to visiting biologists of all nations.

The director and vice-director are members of the faculty of the University of Kief, in Russia, and the station receives annual grants from the Russian ministries of education and marine affairs. Its facilities are also granted without charge to Russian students, who occupy its research tables in considerable numbers every year.

There is no council or board of control of the station. Its entire administration is immediately in the hands of the director, who also selects the staff. A report of the scientific work in progress, with faunistic and temperature records, and some account of the improvements made at the station is published by the director at intervals of several years in the "Bulletin" of the University of Kief.

The station receives from the Russian ministry of education a yearly grant of 10,000 rubles and from the ministry of war for the upkeep of the property an additional sum of 2,000 rubles. There is also an income of about 600 rubles from the sale of collections. The annual expenditure for salaries of the scientific staff is 5,200 rubles, the director and vice-director being paid in part by the University of Kief; for labor and service, including temporary labor, 1,700 rubles; and for upkeep of building, boats, library, and running expenses, 5,700 rubles. An admission fee of 1 franc is charged for entrance into the recently reconstructed aquarium, and a slight increase in funds is expected from this source in future.

The station has thus no administrative relation to any university or educational institution and has no connection with the fisheries. It has all the autonomy of a private institution, but is wholly devoted to research or advanced instruction.

The institution carries on no programme of investigation and issues no publications. Its staff is occupied with independent research, and its doors are open to all qualified investigators and advanced students for such work as they choose to undertake.

Applications for admission should be sent to Doctor Davidoff in advance, stating the period for which application is made and the material desired for investigation. A copy of the "Reglement" and an outline map of the roadstead and vicinity are supplied on application. The laboratory is open throughout the whole year and at a

maximum provides for 30 workers at once. It is visited annually by 30 to 35 investigators, mainly Russians and Germans, with a few from Switzerland, Austria, and France. It is most crowded in March and April. The best season is fall to spring. The summer months are apt to be warm. Villefranche is well supplied with hotels, and pensions and special rates may be obtained by workers at the station. There are 13 simply furnished chambers in the upper story of the building available gratis on application to the vice-director.

For several years past a practical course in marine zoology for advanced students has been offered in March and April, with occasional lectures in German or Russian. The programme includes the following subjects: *Radiolaria,* fertilization, and cleavage of sea urchin egg, *Cœlenterata,* anatomy of *Echinodermata, Nemertina, Polychæta, Heteropoda, Pteropoda,* and *Tunicata.* This predominance of pelagic subjects is characteristic of the rich resources of the station in this field. An honorarium of 50 francs is charged to those attending the course. Students are expected to bring their own microscopes.

Investigators are provided with research privileges, including research table, the supply of living material, and the usual chemicals and reagents, and the use of microtome for a fee of 50 francs per month. Glassware taken away and excessive use of alcohol and expensive reagents are charged at cost of material. The fee may be remitted by the director in exceptional cases. Persons working at the laboratory may make collections for research purposes, but not for university or museum collections. The station issues a price list of animals furnished for exhibiton collections, which includes much choice pelagic material.

The grounds of the Villefranche station are located about midway on the western side of the roadstead of that name, immediately beyond the barracks of the French army, just below the Nice-Monaco tramway, and about 1 kilometer from the railway station. The grounds (about 1,000 sq. m.) adjoin the Boulevard des Casernes, and contain, besides the main building, the porter's lodge and dwelling, the old forge and coal depot of the Russian navy, a court, and two small gardens.

The building itself is a plain and somber structure (Pl. XII, *B*) of two stories and basement, with its long axis running north and south. It faces the roadstead and stands only 3 to 4 m. from the beach and 1 m. above high tide. It was originally used as a prison during the Piedmont régime and later as a naval warehouse. In spite, however, of its nonpromising exterior and lugubrious history, it lends itself admirably to the uses of a biological station. It is a massive masonry structure of rectangular form (9.2 by 35 m.), with corner watch towers now partly removed. (See Pl. XIII.) It originally had a long central corridor (3.2 by 35 m.), with massive

arches in two stories separating long apartments (2.5 by 35 m.) upon either side, while a third even more massive one formed the substructure beneath.

In the present building the central corridor (Pl. XIII), entered from the garden through the vestibule, is two stories (15 m.) in height and still occupies the center of the larger part of the building, and affords access to the working rooms and to the stairs to the second floor, while it also serves as the exhibition hall for the public aquaria, its dim light giving a grotto effect to the room.

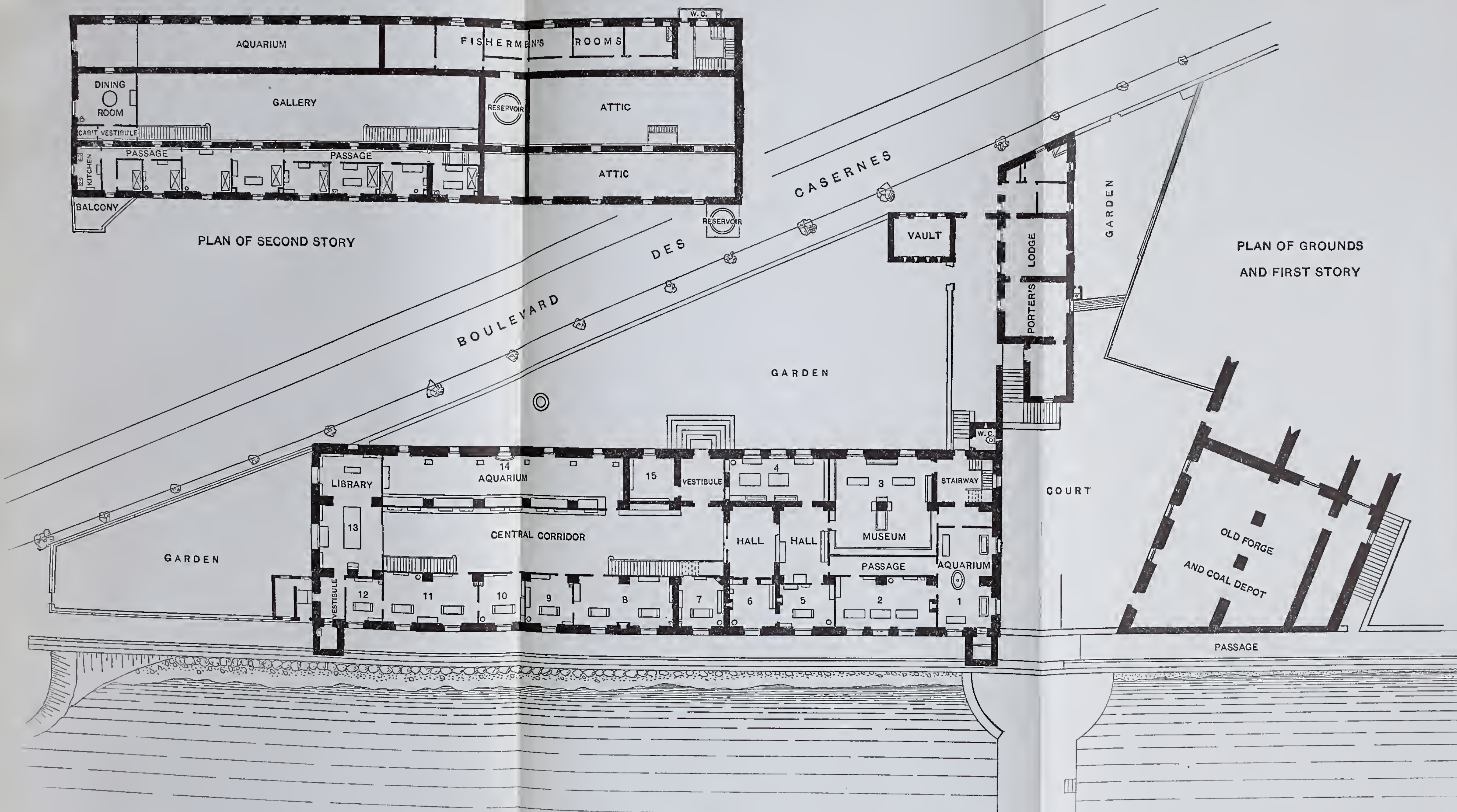
The long apartment upon the seaward side has been broken up into a series of rooms (1, 2, 5–12, Pl. XIII), each including one or two of the structural units (2.5 by 2.5 m.) formed by the arches. Three of these (5, 6, 10) serve as office and laboratories for the director and vice-director and the others as investigators' laboratories. One room (2) is especially designed as a general laboratory for more elementary work. The corner room at the north (1) is an aquarium room for the reception, care, and distribution of the pelagic collections, which are brought daily to the laboratory in the morning during the season. The investigators' rooms are simply furnished with work table (0.8 by 2 m. and 75 cm. high), sink with fresh and salt water, aquarium table (45 by 20 cm.), bookshelves, and several work tables. Gas is supplied to each room, and several of them have paraffin ovens.

At the northern end of the building is a roomy library (3.2 by 6 m.). The side of the building facing the hill is given over to the large attendance room (14, Pl. XIV, *A*), two stories in height, of the exhibition aquarium, which is also used for culture aquaria for investigators. Adjacent to the vestibule are the glassware room (15, Pl. XIII; 2.5 by 2.5 m.) and the preparation and reagent room (4, Pl. XIII; 2.5 by 2.5 m.), and beyond these the museum (3, Pl. XIII; 5 by 5 m.), with exhibition cases about its walls containing a large collection of carefully mounted and fully labeled specimens of the local fauna, principally invertebrates. The representation of the pelagic fauna is exceptionally fine, and includes choice specimens of medusæ, *Siphonophora*, *Heteropoda*, *Pteropoda*, *Cephalopoda*, *Tunicata*, and some fishes.

The upper floor contains the living quarters of the assistant and of the fishermen, and upon the side facing the bay the chambers available for workers at the station and extensive storerooms.

The engine and pump room are in the basement, and here also is found the low-level storage reservoir.

The library contains a fair number of the useful monographs and general works on marine zoology and the reports of the *Challenger*, *Valdivia*, *Belgica*, and other expeditions. It receives over 75 current biological periodicals, and has a number of complete sets, as well as



PLAN OF BUILDINGS AND GROUNDS AT VILLEFRANCHE, FROM DAVIDOFF AND GARYEFF (1908).

a considerable collection of author's reprints. There are about 3,500 volumes with full card catalogue.

At one side of the main hall is a row of nine aquarium tanks of various sizes made of reenforced concrete with walls 8 cm. thick. There are two large rectangular tanks, one 1.2 m. high, 3.55 long and 1.1 wide, the other 1.2 by 3.55 by 1.2 m., each divided into two aquaria. The remaining four tanks have sloping backs (about 50° from the perpendicular) and are used for sessile animals. Two of them are 2 m. wide at the top and 1 m. at the bottom, and the other 1 m. wide at the top and but 10 cm. at the bottom. The walls are coated with artificial rockwork. The openings (1.15 by 2.75, and 1.1 by 1.6 m.) are glazed with plate glass 27 mm. in thickness mounted in the older aquaria against the inner face on iron frames with minium aquarium cement. In the fronts recently renewed the Monaco method of mounting on the outer face is employed. On the fronts of the aquaria runs a projecting shelf 40 cm. in width of artificial stone work reaching to a height of 1.2 m. from the floor, at the level of the bottom of the aquaria. A wide (4 m.) corridor behind the aquaria with two series of windows and large skylight shielded by adjustable curtains furnishes abundant overhead light to the aquaria. The exhibition corridor itself is but dimly lighted. In the rear corridor are five iron stands (Pl. XIV, *A*) with two aquaria each in iron frames with plate glass (7mm.) sides and bottom, the upper one 15 by 22 by 42 cm., the lower 21 by 21 by 48 cm. in height, breadth, and length, respectively; each has overhead water supply and vertical standpipe with surface outflow. On the floor is a semicircular basin 1 by 2.6 m. and 25 cm. deep of reenforced concrete with walls 6 cm. thick. This receives the outflow of all the aquaria and is used for storage. In the smaller well-lighted aquarium room are two large tanks (Pl. XIV, *B*) in iron frames on a cement table 48 cm. high, 61 cm. wide and 165 cm. long with plate glass sides 20 mm. thick. The table has top and uprights of reenforced concrete 9 cm. thick with a floor basin (87 by 156 and 33 cm. high). There is an overhead water supply and standpipe outlet. There is also an elliptical floor basin (1.5 by 1.8 and .25 m. high) with central fountain and walls of reenforced concrete 6 cm. thick.

The circulating system is of lead piping throughout. The mains are 6 cm., the laterals 3 cm., and the terminals 1.8 and 1.2 cm. outside diameter. A hard rubber tip is fastened with rubber tubing at the end of each supply pipe. This is provided with a removable tip with openings 1 to 3 mm. in diameter and is fastened on with rubber tubing perforated for ingress of air. The discharge is carried to the bottom of the aquarium in glass tubing. Each aquarium has its own overflow of 2 cm. lead pipe and a bottom flush of 3 cm. piping. The

outflow mains are of 5 cm. pipe. All cocks and valves are of brass, tinned (in part) on the inside.

The pumping plant consists of a 3 horsepower electric motor and a Jaegar rotary pump of phosphor bronze with a ¾ horsepower hot-air pump of Böttger in reserve. The water is drawn from the surface at the margin of the quay through a 4 cm. (internal diameter) lead pipe 28 m. long. The water for the exhibition aquaria is pumped to a cylindrical reservoir (diameter 3.8 m., height 2.62 m., capacity 28 cu. m.) of reenforced concrete with walls 6 cm. thick, located in the central hall in the second story, at an elevation of 15 m. above the pump. The water for the laboratory circulation is pumped to a similar tank (diameter 3 m., height 2.8 m., walls 6 cm. thick, capacity 18 cu. m., elevation 18 m.) in the open air on the corner tower. Waste water from both systems is passed to a basement storage tank 3.8 by 9.25 m. and 1.17 m. deep with masonry walls 40 cm. thick. The system of circulation is closed and the water is used for periods of about ten days before renewal. The shore waters in the roadstead are quickly rendered turbid by shore deposits in rough weather, necessitating a closed system. The laboratory and aquarium circulation are connected but may be used independently.

The Villefranche station is equipped for morphological and observational work, but has no special apparatus for hydrographical (chemical), physiological or bacteriological investigation. There are several high-grade microscopes, six microtomes of Jung, Leitz, and Becker pattern.

The station is fortunate in the possession of a modern motor boat, The *Vellela*, of 7 tons capacity, length 11 m., width 2.8 m., draft 1 m., with a 6 horsepower naphtha motor. She is a kedge-rigged wooden boat with sail large enough for independent navigation and small closed cabin amidships and forward. The equipment consists of two hand winches with 2,000 m. each of 2 mm. and 5 mm. galvanized steel cables for sounding and dredging. The tackle includes the usual tow nets and dredges and a Chun-Petersen closing net, a Nansen closing net, and Negretti-Zambra reversing deep-sea thermometer. The station has also several small boats for shore work.

The temperatures, salinities and tidal conditions are essentially like those at Monaco as is also the character of the shore and bottom, but there are wider stretches of shallow water. A considerable extent of shallow rocky and weedy bottom up to depths of 100 m. is found in the roadstead itself. The shores are everywhere steep and rocky and near the mouth of the bay the water deepens quickly to 500 m. and reaches over 1,000 m. within 5 kilometers from the shore.

The pelagic fauna at Villefranche is especially rich, many forms (e. g., *Histioteuthis* sp.) known elsewhere only from deep waters

A. SERVICE CORRIDOR OF EXHIBITION AQUARIA WITH FLOOR TANK AND SMALL AQUARIA IN IRON STANDS.

B. TABLE AQUARIA WITH FLOOR TANK IN AQUARIUM.

ZOOLOGICAL STATION AT VILLEFRANCHE.

having been taken here at the surface. The pelagic fauna is most varied and abundant in the colder months of the year.

The climatic advantages of the French Riviera, the superb pelagic fauna, the pure water and the roomy laboratories at Villefranche offer great attractions to the biologist wishing to work upon plankton problems or upon experimental work where close approach to natural conditions is essential.

Literature: Davidoff (1896), Davidoff and Korotneff (1897), Korotneff and Davidoff (1901), Davidoff and Garyeff (1906, 1907), Dean (1894), Francotte (1907), Gruvel (1898), Sand (1897).

INSTITUTE OF MARINE BIOLOGY OF THE UNIVERSITY OF LYON, TAMARIS-SUR-MER (VAR).

Director, Prof. Raphael Dubois, Laboratoire de Physiologie, Université, Lyon, April–September. At Tamaris the remainder of the year.

The corner stone of this station was laid in 1891, and the building was completed in 1900, on ground given by Michel Pacha, general administrator of the Ottoman light-house service and resident of Tamaris. The University of Lyon granted a sum of 42,000 francs for the building, and subventions have been received from the Department of Var; the commune of Seyne-sur-Mer, in which Tamaris is located; the French ministries of marine and public instruction; the French Association for the Advancement of Science; the Society of Friends of the University of Lyon; the founder, Professor Dubois; and numerous private donors. The laboratory also inherited the library, collections, and equipment of the earlier laboratory of Professors Fol and Barrois at Villefranche. The equipment for the laboratories was furnished by state funds.

The laboratory is an annex of the chair of physiology at the University of Lyon and is occupied by Professor Dubois from September to April, being closed during the warm season.

The station, with adjacent garden, lies on the Rue de la Sablettes, which runs along the water front from the steamer landing at Tamaris. It is readily reached by small steamers, which make hourly trips from the Quay de Cronstadt in Toulon to watering places along the Bay of Toulon. Tamaris lies on the northwest shore of the Rade de Lazaret, opening to the northeast into the Grande Rade du Toulon.

The building stands about 10 m. from the water front and 1.5 m. above high water. It is rectangular in form, with its long axis running north and south, and faces the east. It is a Moorish structure of two stories, built of masonry, elaborately ornamented and decorated, forming a prominent feature in the landscape of the picturesque shore.

The northern half of the building (9 by 35 m.) is given up to the scientific laboratories and the southern to the quarters of the attendant and the residence of the director. On the ground floor is a collection room (6.5 by 8 m.) containing a small (mostly unnamed) collection of the local fauna, especially of lamellibranchs, and a library of about 500 volumes, mainly French journals and works on physiology. Adjacent to this is a physiological laboratory (6.5 by 6.5 m.) equipped with a chemical hood, balances, thermostat, autoclave, manometer, mercury pump, operating table, and considerable apparatus of simple types for work in electro-physiology. There is also a paraffin oven, a rocking microtome, and a Berthiot micro-photographic apparatus, with adjacent dark room. A receiving room (3 by 2 m.) is used as storeroom for nets, dredges, and fishing tackle, of which the station possesses a simple equipment. Between the library and laboratory is a small (2 by 3 m.) reagent and balance room.

On the upper floor is the study of the director and three small laboratories about 2 by 3 m., each simply furnished, with work tables and sink. Adjacent are two chambers available for workers.

In the garden of the institute is an animal house for rabbits and guinea pigs and an aquarium house (5.4 by 6.5 m.), with adjacent pump house (2 by 7 m.), with a Niel gas motor and a brass plunger-pump. In the aquarium house are a cement reservoir, four floor tanks of cement (one with heating apparatus), and numerous culture basins of glass, marble, and galvanized iron. The circulating system is of lead, with brass cocks and valves.

In front of the station, on the shore, is a small oyster park about 10 by 35 m., inclosed with stone wall, for experimental culture work with oysters and other invertebrates.

The station has three boats for field work.

Application for admission should be sent to the director. A fee of 50 to 60 francs per month is charged for lodging and the use of a private laboratory. In certain cases free admission will be granted.

The investigations carried on at the laboratory are published in the "Annales de la Université de Lyon."

Literature: Sand (1897), Caullery (1899).

MARINE ZOOLOGICAL LABORATORY OF THE UNIVERSITY OF AIX-MARSEILLE (LABORATOIRE MARION) AT ENDOUME, NEAR MARSEILLE.

Director, Prof. Et. Jourdan, Laboratoire de Physiologie, École de Médecine, Université, Marseille; residence, 8 Rue de la Bibliothèque.

In addition, one keeper, a machinist, and a collector.

The station at Marseille owes its origin to the efforts of Prof. A. F. Marion, the distinguished naturalist of that city, for many years the director of its Natural History Museum and professor of zoology in

its faculty of sciences, with which he was connected throughout his academic career. In 1872 a small marine laboratory was opened in the Allée de Meilhan, with Doctor Marion as director. Advanced to the chair of zoology in 1876, he threw his whole soul into building up the Marseille station. The years from 1876 to 1882 were brilliant years for the laboratory, being marked by the presence of a group of Russian, German, and Spanish savants, led by the noted Russian embryologist Kowalewsky and by many French students, who carried on their researches for their doctorates under Marion's guidance and inspiration. In 1888 the crowded quarters of the old laboratory were replaced by a modern building at Endoume, erected by the city on ground belonging to the university.

The investigations of the earlier years of the laboratory were published in a series of monographs in the "Annales" of the Marseille Museum. In later years the work of the laboratory was directed largely toward the solution of practical problems of the fisheries. At present the station is used largely for elementary and advanced instruction and provides the laboratories for university classes in zoology and biological chemistry.

Upon the death of Professor Marion in 1896, Prof. Et. Jourdan, professor of physiology, was made director. Associated with Professors Marion and Jourdan as assistant director was Dr. Paul Gourret, after whose death, in 1903, Dr. P. Stephan was called to the post. The vacancy created by Doctor Stephan's death in 1908 has not been filled.

The Marseille station receives 4,000 francs per annum from the university for the upkeep of the building and equipment of the laboratories and 2,000 francs from the city for the maintenance of the aquaria and collections.

The Marseille station is open throughout the year to properly qualified investigators. No charges are made to savants, but students are expected to conform to the university regulations regarding fees (30 francs annual fee and 50 francs per trimestre for research) and admission. All laboratory facilities, instruments, reagents, and material for research are provided in so far as the equipment and budget of the laboratory permit. Application should be made in advance to the director. The station maintains no biological supply department.

The Marseille station is located in Endoume, a suburb of the city on the coast about 3 kilometers southeast of the "Vieux Port," whence it is reached in a half hour by the Bourse-Prophete tram on the famous Promenade de la Corniche. Descending from this on the Martin Cascade we come to the Rue de la Douan, upon which the laboratory is located in irregular grounds of small extent immediately upon the sea front.

The building (23.5 by 40.5 m. in extreme dimensions) is cruciform in shape, with the long axis running northwest by southeast, with the right transept in the form of a round tower. It stands fronting the sea about 25 m. above sea level and about 35 m. from the rocky face of the cliff. It is a masonry structure built of local rubble and trimmed with cut stone, three stories in height, except for the nave, which has but two stories. A basement room extends for a short distance under the outer end of the nave and projects beyond it as a one-story structure on the sloping face of the cliff upon which the building stands.

The basement room (9 by 13.5 m.) contains a large low-level storage reservoir and serves also as a storeroom. The left wing of the transept (5.5 by 8.5 m.) at the basement level opens upon the adjacent garden, and, with the corresponding part of the first floor, contains four rooms of the living quarters of the keeper and machinist.

The right wing of the transept (7 by 9 m.), terminating in a circular tower (7 m. in diameter) with bastions, contains the stair well and stairs, and on the third floor the salt-water reservoirs.

The first floor contains in the center of the transept a large vestibule (4 by 7.5 m.), whose walls are hung with models of tackle and apparatus used in the local fisheries and for biological collecting. Adjacent is a small storeroom (1.5 by 5 m.), used for tackle, nets, etc. The nave of the ground floor is entirely given up to the room (8.5 by 20 m.) for the exhibition aquaria and to the display of collections, models, and apparatus pertaining to marine work and the fisheries. Beyond the vestibule at the opposite end of the building is the room (8 by 8.5 m.) now used as the laboratory of biological chemistry of the university.

The second story contains, in the left transept, the private physiological laboratory (5.5 by 8.5 m.) of the director, and in the nave the laboratory (6.5 by 8.5 m.) for the courses, and two (each 6 by 6.5 m.) for Professor Darboux and his assistants of the department of zoology of the university. An adjacent corridor and the centrally located vestibule contain exhibition collections of the local fauna, carefully mounted and labeled. There are also a dark room for photography (1.5 by 4 m.) and a well-lighted library (6 by 8.5 m.), with portraits of Marion, Gourret, and Stephan, with adjacent office of the director (2.5 by 5 m.).

The third story includes only the transept and the apse, the roof of the nave forming a protected terrace (8.5 by 9.5 m.) commanding a magnificent view of the Gulf of Marseille. On this floor is a room (5 by 5 m.) equipped with apparatus for photographing living animals, and also for microphotography, with dark room adjacent. A small laboratory (2.75 by 5 m.) is set aside for physiological work, and two others of the same size and a third (5 by 5 m.) somewhat larger are available for visiting naturalists. These laboratories are simply fur-

nished with work table, shelving, and sink, and are supplied with gas and fresh water, but not with aquaria or salt water.

The aquaria of the laboratory are located on the ground floor and form a covered darkened arcade (Pl. XV, *A*) (4.4 by 10 m.) with central passageway 2.25 m. wide with a bank of six aquaria upon either side. The tanks rest upon an arched structure of masonry with marble top 1 m. high and 0.9 m. wide, with cement drip basin beneath.

The tanks have marble base, back, and partitions, held together in cast-bronze frames (about 5 by 7 cm.) on the angles. The marble and glass are set in litharge aquarium cement. The tanks are rectangular in form and are all of the same size, 1.65 m. long, 0.80 m. wide, and 0.78 m. deep and capacity of 1 cu. m. each, with plate glass fronts 80 by 160 cm. and 30 mm. thick.

A varied assortment of animals representing the local fauna is kept on exhibition, principally small fish, actinians, crustaceans, mollusks, tunicates, and echinoderms. The aquarium is open to the public without charge on Sundays and holidays, and on other days on application to the keeper.

The pumping plant is at a level of 7 m. above the sea and consists of a three-fourths-horse power Blanc gas motor and a Lavigne direct-action plunger pump of brass with adjacent copper strainer and connecting pipes of the same material. The sea pipe (5 cm. outside diameter) is of hard lead 12 m. in length to the pump and 80 m. thence to the reservoir at an elevation of 35 m. above sea level, in a lead pipe of 8 cm. diameter. The reservoirs are 6 in number, containing 1 cu. m. each of masonry lined with marble slabs. The distributing system is lead piping with mains 5 cm. and laterals of 3 cm. The terminals are of lead-lined copper pipes 1 cm. in diameter. The cocks are of bronze throughout. The aquaria are supplied with water from above and discharge through glass tubing carried to the bottom, with orifice for admission of air in the rubber connections. The outflow is drawn off at the surface in two 3 cm. lead pipes set at different levels in the rear wall of the aquarium and connected below with glazed tile, which carries the discharge into the storage reservoirs in the basement. The tanks are also provided with bottom flush plugs. The basement reservoir (3 by 6 m. and 1.8 m. deep) is used for large animals and for reserve stocks of material. It discharges directly to the sea, the water being used but once in the aquaria.

The Marseille station being also the zoological laboratory of the university has a complete equipment for morphological work. The physiological equipment of the university is, however, at the medical school. There is no equipment of hydrographical apparatus. The field equipment consists of a small sailboat and a fair supply of dredges, trawls, nets, tow nets, fish traps, etc., for routine collecting.

The library contains several hundred volumes of special works and serials dealing with marine zoology, and may be supplemented by that of the university and the museum in the city.

The local conditions are not very different from those at Villefranche save that the coast is more densely populated and the otherwise clear blue water somewhat contaminated by sewage. The shores are steep and rocky, affording little shelter for boats and no extensive flats for shore collecting. The bottom fauna is, however, rich and varied. A very full account of the fauna and its local distribution is given in the first memoir of the "Annales du Musée d'Histoire Naturelle de Marseille" by the founder of the station, Professor Marion.

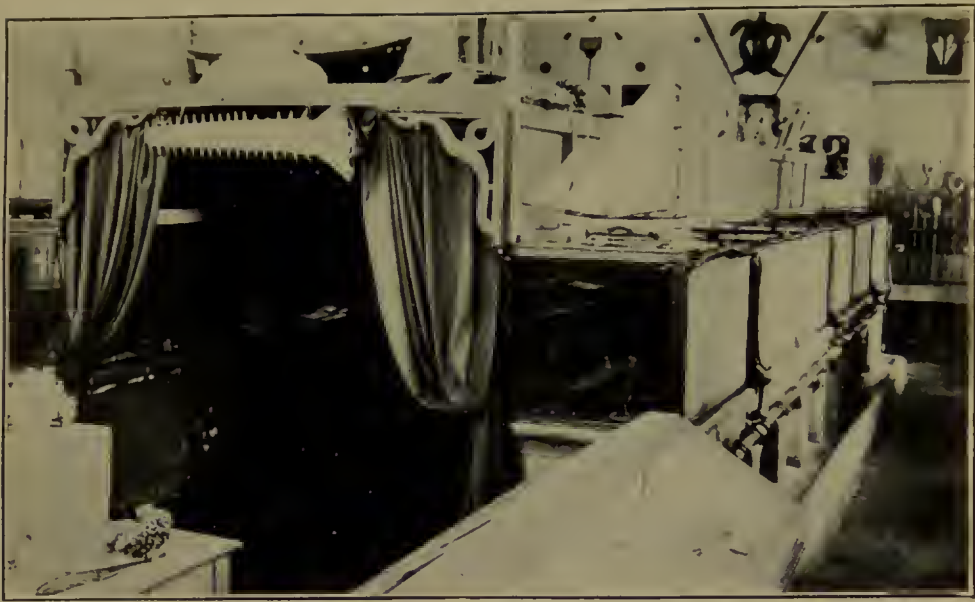
Literature: Dean (1894), Gruvel (1898), Jourdan, Vayssiere et Gastine (1897), Sand (1897).

ZOOLOGICAL STATION OF CETTE (HERAULT).

Director, Prof. O. Duboscq, Laboratoire Zoologique, Université, Montpellier (Herault), France; professeur de zoologie, Université, Montpellier.
Vice-director, Dr. L. Calvet, Montpellier.
Preparator, Lic. Sci. B. Collin, Cette.
Collector and keeper, B. Marquès.

The station at Cette had its origin in the need of the University of Montpellier for field headquarters at the shore for its teachers and students in zoology, and owes its foundation and development to the untiring efforts of Prof. Armand Sabatier, for many years professor of zoology in that university. His success as a teacher and administrator was such, and the confidence he inspired so great, that he was able to command sufficient support, in the communities in which he labored, to build up a fine station.

In May, 1879, the first station at Cette was opened in the cottage of Marquès the fisherman, ever since attached to the institution. Harbor improvements and the growth of the enterprise necessitated several changes, and in 1884 the city of Cette placed three rooms in the École Victor Hugo at the disposal of the station, and in 1886 the station was attached to the École pratique des Hautes Études. These quarters were occupied until 1896, when part of the present roomy building became available. In the little laboratory in the École Victor Hugo, university classes and teachers met with enthusiasm on the weekly excursions to the seashore, and many French and foreign savants (Vogt, Fol, H. de Varigny, Roule, Koehler, and others) carried on their researches and brought their classes from other universities. The lack of sea-water circulation and the urgent need of more room led the director to institute in 1886–87 a series of public lectures in Montpellier and Cette, in which he set forth the educational, scientific, and practical value of biological stations.



A. AQUARIUM ROOM, MARSEILLES STATION.

B. GENERAL VIEW, ZOOLOGICAL STATION AT CETTE.

His efforts resulted in the formation at Cette of a local society to further the project, and in a subscription of 19,000 francs by friends of the movement. From the ministry of public works, through the minister, M. Yves Guyot, the station received 3,500 sq. m. of land on the shores of the Étang de Thau, at the entrance of the canal which connects this lagoon with the sea. The department of Herault in 1892 appropriated 10,000 francs, the city of Montpellier 50,000 francs in 1893, the city of Cette 75,000 francs in 1896, and the director of higher education 50,000 francs in 1897–98, a total of 185,000 francs, for the erection of the building which was commenced in 1892. Owing to the nature of the ground much time and money were consumed in securing adequate foundations, and it was not until 1896 that the station moved into its new and, then, but partially completed quarters. Upon the occasion of the twenty-fifth anniversary of the founding of the station, in May, 1904, the pupils and friends of the founder presented to the station a marble bust of Professor Sabatier by the sculptor Bassan, which now adorns the main hall of the building.

Upon the retirement in 1904 of Professor Sabatier, the directorship of the station was transferred to his successor at Montpellier, Prof. O. Duboscq, the present director.

The station at Cette is attached to the University of Montpellier, 28 km. distant, and is directly connected with its department of zoology, its entire staff being members of that department and receiving salaries directly from the university. The institution is, moreover, intimately associated with the instruction given in zoology, university classes in that subject meeting at the station weekly for a full day's session from March to July. The station also serves as research laboratories for the staff and advance students of the department.

The station is equipped for research and is open to all qualified investigators without charge on application to the director. A private room with the necessary glassware, reagents, etc., and animals for investigation, or the means of collecting them, are provided, and use of the excellent library and experimental aquaria is also granted. Microtomes are provided, but investigators should bring their own microscopes. The station has four furnished chambers the use of which is given to workers at the station for a nominal fee of 10 francs per month for service. Collecting for scientific and educational purposes is permitted and animals for research and instruction are supplied gratis to applicants elsewhere, the recipient bearing the expense of containers, reagents, and shipping. The station is open throughout the year with the préparateur and keeper in residence. Its rooms are most used in the Easter and summer vacations and upon Saturdays.

The station has no direct relation to the fisheries, but serves certain general interests by opening its aquarium to the public two days in the week. It also entertains excursions of students from the universities, normal, and secondary schools, and has from time to time conducted special classes for the pupils in the public schools of Cette.

The station at Cette has no general programme of research or exploration, each investigator working independently upon his own problems. The lines of investigation carried on have been mainly morphological or monographic upon marine invertebrates, especially bryozoa and annelids, and at present much of the research work is centered upon the marine Protozoa.

The results of the research have been published widely in many biological periodicals, some of which (works by Professor Sabatier) have been reissued under the title "Travaux de l'Institut de Zoologie de Montpellier et de la Station Zoologique de Cette, Première Série." A second series of independent memoirs bearing the same general title has been issued since 1885 and contains (1908) eighteen numbers.

The station receives but 3,500 francs per annum for its material upkeep. The entire staff is paid from the university budget and receives no special salary from station funds. The university also maintains the library and publications, and the equipment is intimately associated with that of the laboratory at Montpellier. The budget is made up from several sources, the university, the state, and the city of Cette each contributing 1,000 francs, and the department of Herault 500 francs per annum.

Cette is a provincial town, west of Marseille, near the middle of the shore of the Gulf of Lyon. It is the center of a large wine trade, and an important fishing port both for sea fisheries and shell-fish. It is reached by train in six hours from Marseille via Montpellier and lies on the route from Marseille to Banyuls-sur-Mer.

The station at Cette is located on l'Étang de Thau, a large coastal lagoon at the point where its main outlet, the Canal de la Bordigue traversing the city of Cette, leaves the lagoon for the sea. It is several minutes' walk from the railroad station, via the Pont Carnot and Quai de Bosc.

The building stands in grounds (42 by 60 m.) protected by a high iron fence. Its main axis runs north and south, parallel to the canal from which it is distant about 30 m. It stands at an elevation of 1.5 m. above high tide.

The station is a plain, well proportioned rectangular structure (14.32 by 41.38 m.) of masonry (Pl. XV, *B*) finished in stucco and dressed limestone with roof of red tile. It contains three floors above the basement and consists of two end sections (9 by 14.32 m.),

each full three stories in height and a central section (11 by 23 m.) of two stories and an attic.

The building is surrounded on all sides by a stone walk 1.2 m. wide projecting from the wall. It is entered at the south end by stairs ascending to the first floor 1.85 m. above ground level, affording abundant illumination for the basement, which is excavated throughout.

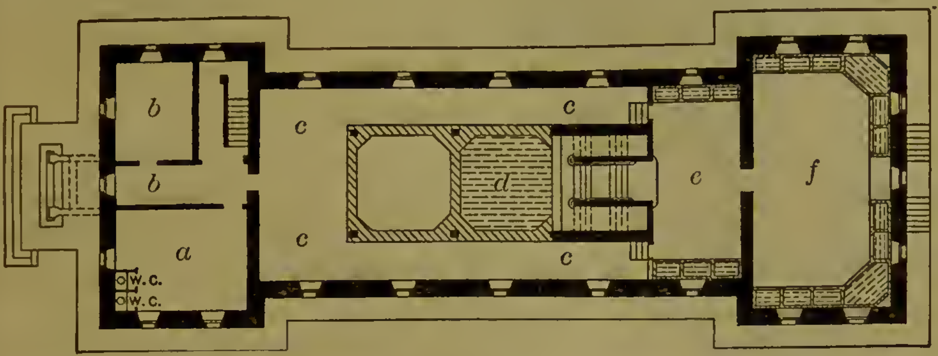


FIG. 4.—Basement floor, zoological station at Cette. From Calvet (1904).

The basement floor (fig. 4) is given over to the storeroom for fuel (*a*, 5.2 by 6 m.), the photographic dark room (*b*, 4.2 by 5.2 m.), a large room (*c*, 10 by 20.5 m.) containing the cooling basins for the aquarium circulation and numerous tables for small aquaria. The remainder of the basement contains the exhibition rooms of the public aquarium, a small hall with aquaria at the ends (*e*, 5 by 8 m.), and a larger one (*f*, 6 by 11.5 m.) with its corners obliquely cut off, surrounded on three sides by exhibition tanks.

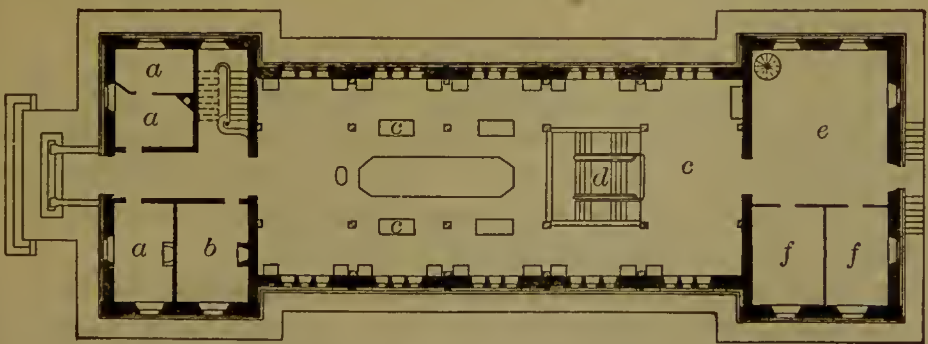


FIG. 5.—Ground floor, zoological station at Cette. From Calvet (1904).

The first story (fig. 5) of the building contains the living quarters (rooms *a*, *a*, *a*) of the keeper, the dining room (*b*, 4 by 5.5 m.) for the staff or for classes from the university. The main section of the building is given over entirely to the museum (*c*, 11 by 23 m.), containing an exhibition of the local fauna arranged in 24 well-lighted glass cases. In this hall stands the marble bust of the founder. On the walls near the entrance are lists of the benefactors whose gifts have contributed to the erection and equipment of the station.

The northern wing, originally a part of the museum, is now divided into a large general work room (*e*, 6 by 8 m.) and two research laboratories (*f*, *f*, each 3.2 by 5.2 m.). From the larger room a spiral iron stair ascends to the floors above.

The second story (fig. 6) contains the main working rooms of the station. The southern wing has the office (*a*) and private room (*b*) of the director and that (*c*) of the vice-director. Adjacent, are stairs to the floor above. At the end of the central corridor a door opens directly into the large well-lighted general laboratory (*d*, 10 by 10 m.) with table space for 40 pupils. (Pl. XVI, *A*.) At one end of the room, above the door leading to the research laboratories, is the motto of the founder, "Partout est la vie." Upon either side upon the walls are paintings by artist friends of the station; upon the right, "The fishermen," by Leenhardt; upon the left a brilliant painting by Professor Balaman of a charming bit of the local coast in the evening sunlight.

From a central corridor leading to the large well-lighted library (*f*, 7 by 12.5 m.) open six research laboratories (e_1–e_6), each about

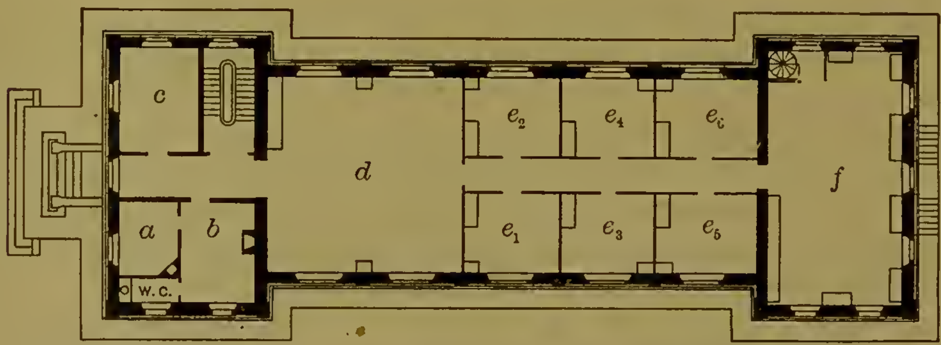


FIG. 6.—Upper floor, zoological station at Cette. From Calvet (1904)

4 by 5 m., abundantly lighted by a window 2 m. in width, and simply furnished with work tables facing the window, chest of drawers, shelving, sink with salt and fresh water supply, gas with hood. The rooms are heated by coal stoves. One of these laboratories is at present used as a glassware room.

The third story contains four furnished chambers, the reservoir for the laboratories on the floor below, and several large storerooms.

The small annex (6 by 14.25 m.) of one story, north of the main building, contains a well-lighted experimental aquarium room and a dissecting room (5.5 by 6 m.), a shop (3 by 3 m.), and machine room (5.6 by 6 m.). The floor of the aquarium room is of cement and slopes to a central drain. The water tower with the reservoir supplying the aquaria and the windmill are adjacent to the annex.

The intimate association of the station at Cette with the laboratories at Montpellier insures adequate equipment of chemical reagents, glassware, and instruments for all lines of morphological

A. INTERIOR OF GENERAL LABORATORY.

B. EXPERIMENTAL AQUARIA, FROM CALVET (1904).

ZOOLOGICAL STATION AT CETTE.

research and makes possible the prompt supply of any need in these particulars. Provision is made at Cette permanently of numerous student microscopes, two Minot rotary microtomes, paraffin ovens, water still, etc.

The library at Cette is exceptionally good and very fully catalogued. It contains nearly 5,000 volumes, including 123 serials (in 1905, see list in Calvet), and contains the libraries of its founder, Professor Sabatier, and of Doctor Rouzaud, and some gifts from the library of Quatrefrage. The serials include the *Challenger* Reports, the publications of the Naples station and the Institute at Monaco, a very complete representation of French serials, and a number of foreign purchases and exchanges. The library is splendidly organized and has complete author and subject card catalogues and also complete catalogues of the zoological library at the university and of the Academy of Sciences at Montpellier, whence books for use at the station can be secured in twenty-four hours or less.

The collections in the museum include a well-arranged and well-mounted exhibit in glazed cases of the local fauna and a large conchological collection, French and foreign, the gift of Abbé Culliéret. The collection of the local fauna was depleted by the fire at the exhibition in Montpellier in 1896 but has since been in part replenished. The exhibit is arranged systematically and is especially complete in annelids and bryozoans. There is also a small exhibit of oceanographical instruments and models.

The exhibition aquarium rooms in the basement are in grotto style, the light entering through the aquaria which are arranged around the periphery, immediately against the outer wall of the building, and receive the light through basement windows. Wooden doors above the glazed openings provide access to the aquaria for attendance, and the space below is also closed off in cupboards. There are in all eighteen tanks with bottom and partitions of 10 cm. reenforced concrete, resting on masonry walls. Of these tanks sixteen are of about 1 cu. m. capacity, while the two tanks in the corners with hexagonal bases contain 2.5 cu. m. The small tanks are 1.43 m. long, 0.9 m. wide and 0.8 m. high, with the base 0.87 m. above the floor. The two larger tanks have an opening 0.8 by 1.5 m. The plate glass fronts (22 cm. thick) are set in grooves in minium aquarium cement.

In the experimental aquarium room (5.1 by 6 m.) there are four reenforced concrete tables (0.6 by 2.5 m. and 1 m. high) with marginal channels for collection of accidental overflow from aquaria. Each table (Pl. XVI, *B*) carries three fixed aquaria built on the table with plate glass sides 5 mm. thick, held in place in brass angles (2 by 3 cm. and 2 mm. thick), set in the cement table top and held in place at

the top with adjustable brass rods. The top is 10 cm. thick, and rests on walls of the same material 15 cm. in thickness. The aquaria are each 38 cm. wide and 60 cm. long and of three heights, 23, 33, and 43 cm., respectively, on each table. Upon the floor of the room is a semicircular floor tank 3 m. in diameter and 0.5 deep and capacity of 3 cu. m., with concrete wall 30 cm. thick.

The aquaria throughout are supplied with overhead jet from a curved tin-lined copper pipe (6 mm.) and vertical standpipe with surface outflow. A perforated porcelain funnel (part of an incandescent gas fixture) is used for the top of the standpipe to prevent clogging of the outlet. The water is passed but once through the aquaria.

A large assortment of fishes and invertebrates is kept on exhibition in the tanks but the recent industrial development of petroleum refining works at Cette has added greatly to the difficulty of keeping animals alive in the aquarium. The discharge of wastes from the refineries into the Étang de Thau is proving disastrous both to the aquaria and to the fisheries of the region.

The pumping plant consists of an "Aeromotor" specially adapted to operate in the variable and often violent "mistral" which blows during October-May, and a 4-horsepower electric motor with a Thirion horizontal plunger pump of bronze with a capacity of 6,000 liters per hour. The water is drawn from a cistern 3 m. deep and 1.5 m. square, adjacent to the pump room. This cistern is connected with the canal by a cement conduit (0.4 to 0.5 m. in diameter) below the level of lowest water. The water passes through several copper screens before reaching the cistern. From the pump the water passes in subterranean mains to the water tower, to the cold basins in the basement, or to the high-level reservoir in the building. The water tower is a cylinder of reenforced concrete inclosed in an octagonal wooden building resting upon an octagonal masonry foundation 3.10 m. in height. The reservoir is 4.8 m. in diameter and 4 m. in height with walls 20 cm. thick and a capacity of 59 cu. m. The cold basins in the basement are two large reservoirs of 34 and 40 cu. m. capacity, respectively, originally intended as receivers of water from the adjacent canal to be pumped to the aquaria and laboratories. This project was, however, abandoned and the outside cistern and reservoir adopted. To avoid extremes of heat and cold in the water circulating in the aquaria it is carried from the cement reservoir in the water tower through a serpentine pipe immersed in the water of one of the protected reservoirs in the basement. By this means water from the Étang with temperature extremes of 0° and 28° can be delivered to the aquaria at 8° and 16°, respectively, in winter and summer. This system is, however, not used in the temperate seasons of the year.

A high-level reservoir of sheet iron lined with cement of 1 cu. m. capacity is placed on the third floor for supplying the laboratories. The mains are of 8 cm. (outside) cast-iron pipes, the smaller laterals and over-flow pipes of soft lead and the cocks and valves of brass.

The field equipment of the station consists of a small sailboat, an ample supply of dredges, and small collecting tackle. For hydrographical work the station has a Richard water bottle, Negretti and Zambra reversing thermometers, a Leger sounding cup, and a hand-sounding machine with 200 m. of sounding wire. The station is fortunate in having close at hand a number of fishermen's cottages, and in being able to arrange collecting trips with the numerous fishing boats that make Cette their home port. The fisheries patrol steamer *Girelle* (30 m. in length) also provides means for field excursions at sea.

The Étang de Thau is a shallow basin of 7.200 hectares, not exceeding 10 m. in depth. It has great expanses of very shallow water and bottom of sand or mud with large *Zostera* beds and oyster parks. The adjacent coast of the Mediterranean is mainly of a sandy character with bits of rocky shore where the Jurassic limestones are exposed. The adjacent waters of the Mediterranean are also shallow, the 50 m. and 100 m. lines being 12 and 36 kilometers distant, respectively. This extensive shallow area is the principal fishing ground on the south coast of France and affords a considerable variety of sandy, shelly, and some rocky bottom. The temperatures in the Étang range from 4° to 5° in January to 28° in August and the salinity is approximately that of the adjacent Mediterranean.

The local fauna is thus mainly that of sandy shores and bottom, and in the absence of the harder rocks the attached flora is relatively scanty. The bottom fauna is, however, abundant and varied, and especially rich in selachians, lamellibranchs, gasteropods, and annelids. A very full list is published in Calvet's excellent account of the station. The pelagic flora is described by Pavillard (1905).

Literature: Dean (1894), Gruvel (1898), Sand (1897), Calvet (1905).

LABORATORY ARAGO, OF THE FACULTY OF SCIENCES OF THE UNIVERSITY OF PARIS, BANYULS-SUR-MER (PYRÉNÉES-ORIENTALES), FRANCE.

Director, Prof. G. Pruvot, Laboratoire de Zoologie, La Sorbonne, Paris. (At Banyuls-sur-Mer, September to March.)

Assistant director, Dr. E.-G. Racovitza, Laboratoire de Zoologie, La Sorbonne, Paris. (At Banyuls-sur-Mer, March to August.)

Commercy research fellow, Dr. R. Jeannel, Banyuls-sur-Mer.

Assistant to the marine fisheries service, Dr. L. Fage, Banyuls-sur-Mer.

Captain of the *Roland* and mechanician, Mr. Theodore David.

In addition, one keeper and engineer, one pilot and net maker, one fisherman, and one laboratory servant.

Telegraph address: Laboratoire, Banyuls-sur-Mer.

The founder of the station at Roscoff, Prof. Henri de Lacaze-Duthiers, was also the founder of that at Banyuls and was its director till his death in 1900. The winter storms which sweep the northern coasts of France and render marine work perilous and collecting at times impossible, led the director of the Roscoff station to plan a sister station on the southern shores of France, where in winter months work interrupted in the northern laboratory might be carried on under advantageous conditions of climate and amid pleasant surroundings and where the rich fauna of southern waters might be made available for French investigators. Foiled in his efforts to secure a choice location in the harbor of Port-Vendres, because of its possible utility for military purposes in the event of war, Prof. Lacaze-Duthiers turned to Banyuls-sur-Mer, a neighboring fishing village near the Spanish frontier, where local interest in the project was so great that a sum of 25,000 francs was offered, together with a sail boat and a fine location for the building near the mouth of the little bay. The advantages possessed by this location, in addition to the natural conditions of the environment, were the existence of a small fishing fleet and the absence of commercial and industrial enterprises which might endanger the purity of the water.

The laboratory was built in 1881 and bears the name "Laboratoire Arago" in honor of the astronomer-physicist, Dom. F. J. Arago, who was a native of Perpignan, the capital of the Department of the Pyrénées-Orientales. It owes its origin entirely to the enterprise of its first director, who, without aid from the state and in the face of much opposition, carried through the enterprise to a successful issue. The funds came in part from the village of Banyuls-sur-Mer and in part from the Department of the Pyrénées-Orientales.

In 1883 the property was formally transferred by the village of Banyuls-sur-Mer to the École des Hautes Études of the University of Paris, which then made provision for its running expenses. In 1883 the east and west ends of the building were added for the machine room and quarters of the keeper, the interior of the original structure improved, and a windmill and reservoir on the hill above the station added to the equipment, at an expense of 29,000 francs contributed by the provincial council, the municipal councils of Toulouse and Perpignan, and by friends. In 1884 the third floor of the building, containing the living quarters for the workers at the station, was completed and furnished. In 1887 a steam engine and rotary pump were installed to replace the very unsatisfactory windmill. In 1890–91 the ministries of public instruction and of agriculture and the general council of the province contributed the funds necessary for the construction of a large vivier or basin surrounded with walls of masonry for the purpose of culture of marine animals and for a shelter harbor for the flotilla of boats.

In 1893 a new epoch in the life of the station was opened with the gift by Prince Roland Bonaparte of 50,000 francs for a steamship for the station. This ship, the *Roland*, was an iron vessel of 22 tons, and at once vastly increased the facilities for marine exploration and for supplying the laboratories with material for research. The ship added, however, greatly to the expense of equipping and maintaining the station. It necessitated the construction of a dock, excavated in the rock within the vivier, for cleaning and painting the hull, which the warm and saline waters of the Mediterranean corroded with great rapidity. The remoteness of Banyuls-sur-Mer from any great commercial center greatly complicated the question of repairs, a difficulty only solved by the extension of the building and equipment of a machine shop where all necessary repairs could be made.

The station was exceptionally fortunate in securing for its mechanician M. Th. David, a machinist of the first rank in the French naval service. He brought to the station not only great mechanical skill and experience, but a live interest in the problems to be solved, a zeal indefatigable, and an inventive ability little short of genius. The growing laboratory at Banyuls abounds in many details of equipment which attest his high success. It is exceptional among the laboratories of Europe in the extent to which the equipment is constructed in its own shops.

In this same year a photographic atelier perched on the rocks to the rear of the station above a new reservoir of sea water was added to the equipment. The total expense of these improvements, including the *Roland*, was 85,000 francs, and was met in this instance also by the gifts of private donors.

In 1895 the laboratory was enlarged by excavation of the hill to the rear and the erection of a large room of one story with overhead light for the experimental work, and by the extension of the quarters for the machine shop. The equipment was increased by the construction of a sounding machine with 2-horsepower engine, and in 1896 the entire hydraulic system was overhauled and renewed.

The *Roland*, built in 1893, was so corroded by the destructive action of the sea water, in spite of constant care, that it became necessary to replace the ship with another. Accordingly, in 1900, a wooden vessel, also christened the *Roland*, was built on the beach near the laboratory by M. David and equipped with the machinery of its predecessor.

Associated with Professor Lacaze-Duthiers, in the years of growth of the station, as his assistants were Professors Joubin, Prouho, Guitel, and Robert. In 1897 Prof. G. Pruvot, then of the University of Grenoble, was appointed assistant director (sous-directeur) and, upon the death of the director in 1900, was appointed as his successor, and Dr. E.-G. Racovitza succeeded to the post of assistant director (sous-directeur et chef des travaux pratiques).

The station at Banyuls-sur-Mer is an appanage of the faculty of sciences, University of Paris. It is not attached to any university chair, but holds the same relation to the higher authorities which the zoological laboratory of the Sorbonne holds. It is thus autonomous, under the superior authority only of the faculty of sciences, the dean of the faculty, and the minister of public instruction. The director is appointed, after the manner of professors in the university, by the minister, from two nominations made to him by the faculty of sciences, and two others, which may or may not be identical with those of the faculty, made by the council of the faculty. The director is responsible only to the faculty, the dean, and the minister, and makes to them an annual report on the affairs of the station.

The station receives an annual subvention from the ministry of public instruction, in the budget of the faculty of sciences, of 8,000 francs, disbursed at Paris by the treasury on approved accounts. In addition to this subvention, the salaries of the staff, including that of the mechanician and the keeper, are paid from the government budget. There is also an annual subvention of 3,500 francs for fisheries investigations from the ministry of the marine, the station furnishing in return for this sum the use of a research room and placing its facilities for marine research at the disposal of a member of the fisheries staff, the present incumbent of the position being Dr. L. Fage, an assistant in the "Service des pêches maritimes." This association is the only relation which the Banyuls station bears officially to the fisheries.

The Commercy legacy to the University of Paris of 4,000,000 francs provides, among other research fellowships, one of 5,000 francs which is assigned to an investigator who must be resident at the Arago laboratory and render the service of a scientific assistant to the institution. The appointment is made for one year, but may be renewed for two additional years. The present appointee is Dr. R. Jeannel.

Excluding the salaries of the staff as above noted, which are otherwise provided for, the total annual expense of maintaining the Arago laboratory is about 20,000 francs. Of this, 8,000 comes from the budget of the faculty of sciences, 3,500 from the ministry of the marine, 2,000 to 3,000 of the deficit is met each year by the university, and the remaining 6,500 to 7,500 is paid by the director and assistant director and friends of the institution. The expenses are approximately distributed as follows:

	Francs.
Labor	6,000
Library (subscriptions and binding)	1,200
Upkeep of "Roland" and machine shop	8,000
Glassware, reagents, supplies, and miscellaneous	4,800
Total	20,000

The laboratory has no endowment and receives no income from rent of tables or sale of collections.

The aim and purpose of the Banyuls station is primarily that of pure research. No instruction or regular courses are given to students of university grade. The laboratories are not reserved for the students or investigators of any university, but are open to everyone upon the same terms. Students from the Sorbonne frequently come here for their doctorate investigations, but attendance is not obligatory. A remarkable atmosphere of freedom pervades the institution. There are no fees, no rules and regulations, and no restrictions of any sort upon investigators enjoying the hospitality of the station.

Applications for admission should be sent in advance to "The Director," Laboratoire Arago, Banyuls-sur-Mer. Travelers to the station receive permits for half-fare privileges on the railways in France, but application for permits should be filed at least ten days in advance with the authorities of the station at Banyuls. Investigators have the use of a private research room, the supply of living material for research, the use of glassware and chemicals, paraffin oven, and microtome, and also of microscope if desired, but if convenient it is preferred that workers provide their own microscopes or objectives, especially in the case of high-grade instruments. The use of aquaria in the observation room and the privilege of collecting with the marine equipment is also accorded freely. Collecting not only for research but also for university laboratories and public museums is permitted after the research laboratories and the aquaria are supplied. Only commercial collecting is forbidden.

The investigator is free to work as he wishes and to publish his results where he will. The station staff assumes no responsibility for his work. A cordial welcome, however, awaits the worker and friendly advice is freely given.

The laboratory at Banyuls has comfortable accommodations for 12 investigators, but 20 can be provided with working tables at one time, if need be. The number of investigators varies from 20 to 40 per year, the average being about 30. The autumn and spring are the most popular seasons.

The laboratory is open throughout the whole year, but with reduced service and no field work in August. The third floor of the main building contains ten rooms which are comfortably but simply furnished as bedrooms. They are used by guests of the station without charge, save a payment of 10 francs per month to the servant. Arrangements may also be made with the keeper for simple meals or morning "café au lait," and an adjacent hotel or cafés in the town, a few minutes' walk from the station, also afford comfortable

though not elegant accommodations. The best months of the year are September–December and April–July. The summer is apt to be hot, and in winter the cold "mistral" from the mountains sometimes brings chill and discomfort, as well as effectively preventing work at sea.

Banyuls is a quaint fishing village of 3,400 inhabitants, at a considerable distance from any city of importance. It is a summer resort, frequented by excursions from the interior and visited also for its baths. The back country and the adjacent coasts of Spain, with fine mountain scenery and picturesque glimpses of provincial life, afford an attractive field for excursions.

The founder of the Banyuls station had from the first the desire to make the institution one of general service, and planned to use its facilities for the cultivation of popular interest in and knowledge of the life of the sea. To this end an attractive hall, adorned with statuary and surrounded with aquaria, is freely open to the public on five days in the week. Admission has always been free, and by the side of each aquarium is a large blackboard upon which explanatory labels and drawings are placed for the general information of the public. The hall is also provided with seats, and the station possesses a stereopticon which may be used for lectures. The aquarium is often visited during the summer by 600 to 1,000 persons in a single day. In the week of the anniversary (May 10) of the death of the founder of the station the school children of Banyuls assemble at the station for a lecture on the purpose of the station and the life of the founder, with illustrations from the field of marine biology. The men and later the women students of the normal schools in Perpignan make an annual excursion to the station for lectures and demonstrations. Local organizations, societies, Alpine clubs, etc., are also entertained from time to time by popular talks. The directors also give two illustrated evening lectures each year on some biological topic in the neighboring city of Perpignan. Beginning with 1909 the public-school teachers of three provinces are to be received a few days each year for popular instruction regarding the life of the sea. The station is also visited frequently by classes of students from the universities of Toulouse, Montpellier, and Barcelona. Although subject to these invasions of popular and semiscientific excursions, the Banyuls laboratory is so constructed that the work of the investigators need not be disturbed thereby. The research rooms and the aquaria used in investigation are not open to the public.

In the Easter vacation, under the auspices of the directors of the station, an annual excursion from Paris is conducted each year to Banyuls. The itinerary is varied, including about a week at the station, with excursions to sea, collecting trips along shore, lectures and demonstrations in the aquarium hall, and field trips to Corsica,

the Balearic Islands, into Spain, or the Pyrenees. Colleagues from various universities join in the expeditions, which are always conducted by professors in zoology, botany, and geology. These excursions are so planned as to be completed within three weeks and not to exceed 200 francs in cost. Though primarily scientific in purpose and scope, they are open to all properly qualified persons on application. These excursions have been quite popular and membership in them is much sought, 40 to 100 persons sharing in them each year. The excursions are open to foreigners also.

There is one field of activity of the station which though not biological and only remotely affecting the proper work of the station nevertheless strikingly illustrates the spirit of public service which dominates its administration, and therefore merits notice here. Under the guidance of M. David, the expert mechanician of the station, 10 boys from the neighborhood are received annually in the shops for practical instruction in shop practice, and incidentally in methods of marine exploration, supplementing instruction in the public schools with a view to preparation for the competitive examinations for admission to the French school for naval machinists at Lorient. The boys from M. David's hands have an enviable record in this school.

One of the important functions of the Banyuls station is the sending of living animals by parcels post to schools, universities, and investigators. No charge is made for this service beyond the outlay for the packing and shipment, which amount to 4.10 francs per package. Living animals of many sorts are sent safely in this fashion to Paris, and in winter even to Belgium. Many hundreds of shipments are thus made of material for use in laboratory courses in the higher institutions of learning in France and other countries, for the service is not restricted by national boundaries.

The Arago laboratory has had no elaborate plan of investigation. Its directors have always been associated with universities and engaged in instruction, so that a continuous or regular plan of exploration or investigation has been impossible. Many important morphological, embryological, and systematic investigations upon the marine fauna have been made in its laboratories, and the results of its explorations of the Gulf of Lyon between Cette and Barcelona are accumulated in an orderly manner, looking toward their coordination in a systematic account of the oceanography and marine zoology of this region. Several preliminary papers on the subject have already been published in the "Archives de Zoologie expérimentale et générale."

Banyuls-sur-Mer is located about 6 kilometers from the Spanish frontier on a diminutive roadstead of the same name which is open to the northeast. It is reached by rail from Paris in fifteen hours via

Narbonne, or in about five hours from Cette. The Marseille-Algiers steamers call at Port Vendres, 5 kilometers up the coast. The station is located on the southern shore of the roadstead near its entrance, about ten minutes' walk from the local railway station.

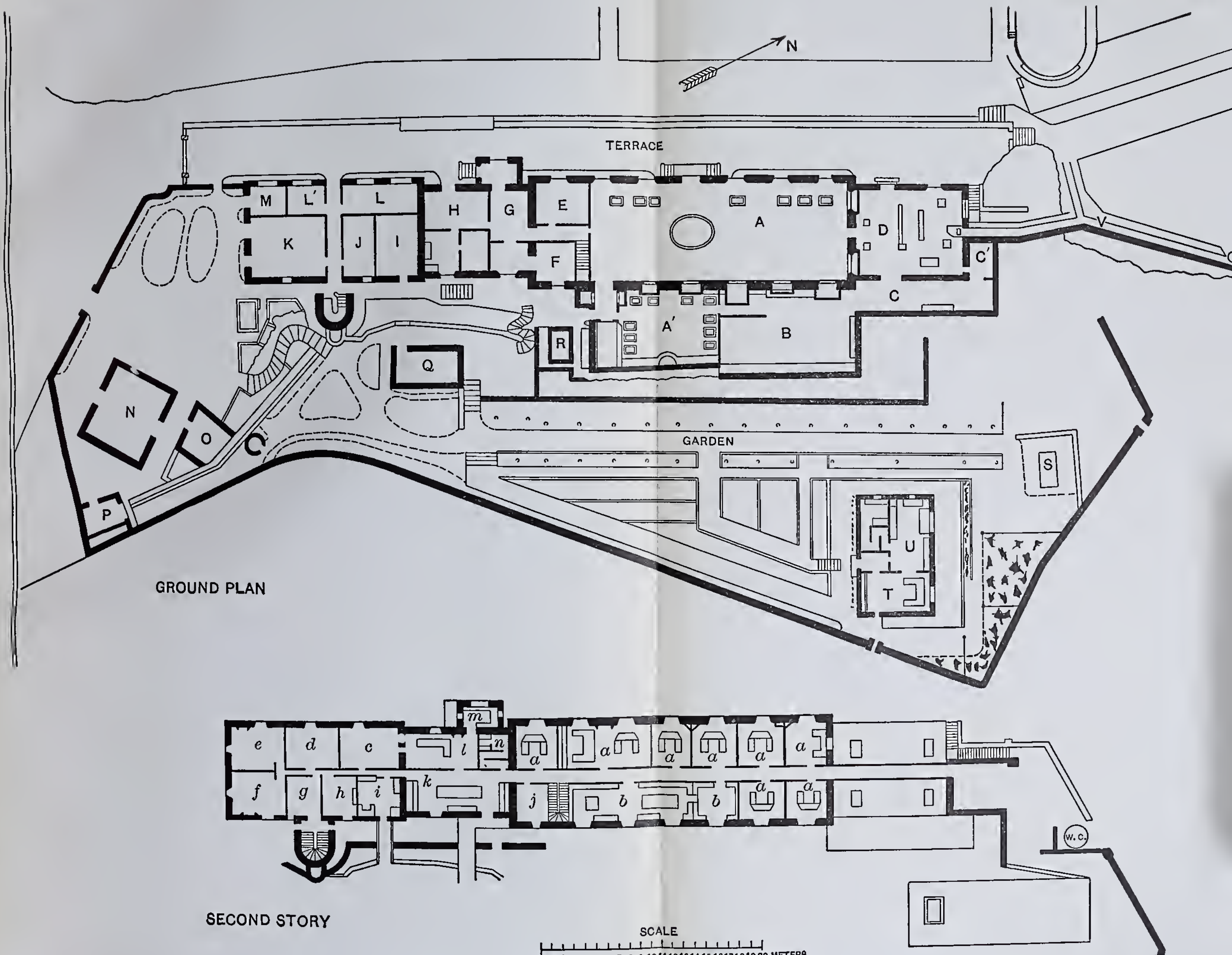
The grounds (Pl. XVII), which contain 10,852 sq. m., are of irregular form on the steep, rocky hillside, which has been excavated to make room for the main building and some of its adjuncts. Located on the grounds are the main building of the station (Pl. XVIII, *A*), with the adjoining building containing quarters for the keeper (Pl. XVII, *H*) and the residence of the director (*c*, *d*, *e*, *f*, *h*), and also some additional rooms of the station. There are also on the grounds the photographic atelier (*T*, *U*), the acetylene house (*P*), the greenhouse (*Q*), aviary (*R*), laundry (*O*), and a small cottage, and projecting into the harbor two moles, one of which forms one side of the vivier or safety harbor, in which is located the dry dock for the ship.

At the edge of the cliff overlooking the sea is the tomb of the founder, soon to be marked by a fine bronze statue by the sculptor, Beulliure.

The main building (Pl. XVIII, *A*) is a perfectly plain barracks-like structure of three stories of rectangular form (10 by 29 m.), with its adjuncts covering 1,145 sq. m., built of the local metamorphosed schists quarried on the spot. Its long axis is parallel with the water front and runs east-northeast by south-southwest. It faces the harbor, standing at a distance of 9 m. from the sea wall and 4 to 5 m. above sea level.

On the ground floor is a large aquarium room (*A*, 10 by 23 m.), the office (*E*, 4 by 6 m.), and small museum or collection room (*F*, 4 by 4 m.). The one-story extension to the northeast contains the machine shop (*D*, 8 by 10 m.). To the rear of the machine shop are several one-story buildings with skylights containing the smithy (*C*, 3 by 12 m.) and oil tanks (*c′*), the carpenter and repair shop (*B*, 8 by 12 m.), and the experimental aquarium room (*A′*, 7 by 12 m.). At the other end the main building is continued at a lower level in a slightly narrower extension of three stories (9 by 27 m.), which has on its ground floor the vestibule (*G*), keeper's quarters (*H*) of three rooms, glass room (*I*, 3 by 6 m.), storeroom (*J*, 4 by 6 m.), and a large room (*K*, 6 by 7 m.) for nets, tackle, cordage, and sails, two small laboratories (*L*, *L′*, 2.5 by 12 m.), and a bathroom (*M*, 2.5 by 4 m.).

The third floor of this part of the building is at the same level as the second floor of the main building. This floor contains, as shown (Pl. XVII, second floor), a long, central corridor, opening from which are seven investigators' laboratories (*a*, 4 by 4 m.), the office and laboratory (*a*, 4 by 8 m.) of the assistant director, the large library rooms (*b*, *b*, 4 by 16 m.), and the reagent room (*j*, 3 by 4 m.). From the corridor, stairs ascend to the fourteen chambers on the third floor



PLAN OF THE LABORATOIRE ARAGO.

Ground floor: A, Public aquarium. A′, Experimental aquaria. B, Carpenter and repair shop. C, Smithy and oil reservoirs. D, Machine shop. E, Office. F, Museum. G, Vestibule. H, Keeper's quarters. I, Glassware storeroom. J, Storeroom. K, Tackle and net room. L, L′, Laboratories. M, Bathroom. N, Cottage. O, Laundry. P, Acetylene house. Q, Greenhouse. R, Fresh-water reservoir and aviary. S, Tomb of Professor Lacaze-Duthiers. T, Laboratories. U, Photographic studio. V, Tunnel for sea pipe.
Second floor: *a*, Laboratories. *b*, Library. *c*, Parlor. *d*, Dining room. *e*, Chamber. *f*, Chamber. *g*, Office. *h*, Kitchen. *i*, Laboratory. *j*, Reagent room. *k*, Collection and preparation room. *l*, *m*, Laboratory of the director. *n*, Dark room.

After drawings furnished by Doctor Racovitza.

of the main building, and lead directly into the collection and preparation room (*k*, 4 by 12 m.), from which open the dark room (*n*, 2.7 by 3 m.) and the laboratories of the director (*l*, *m*, 3.5 by 7 and 2 by 3 m.) and Madame Pruvot (née Fol) (*i*, 4 by 4 m.). The remainder of this floor (*c*, *d*, *e*, *f*, *g*, *h*) is occupied by the office and residence of the director. Iron bridges lead from this floor to the garden on the hill at the rear, where is located the photographic studio, and above the shops to the terrace at the sea cliff.

The aquarium room (Pl. XVIII, *B*) of the Banyuls station is used also as a small assembly hall.

About the hall is a row of busts—Æsculapius, Descartes, Lavoisier, A. L. and B. Jussieu, Linné, Laperouse, Forbin, Pascal, Ducouédic, Duhamel, Buffon, Réaumur, and Daubenton—the gift of the Academy of Fine Arts, and at the far end of the hall is a cast of the Venus of Milo. On the frieze above the busts is the motto "La Science n'a ni Religion ni Politique," the motto of the founder. A replica in plaster of the bronze bust of Professor Lacaze-Duthiers, given to the faculty of sciences at Paris by the faculty of the University of Barcelona, stands upon the lecture desk.

The windows are draped with heavy curtains to give the desired grotto effect to the room. An arc lamp with powerful reflector, used for the illumination of the aquaria for evening demonstrations, is provided in the lecture hall.

There is a bank of seven wall tanks along the end and the east wall, with three additional ones in the passage at the rear. These tanks are set in arches of the masonry wall and rest on masonry foundations. They are built of brick faced with cement, and their dimensions (external) are 2 m. long, 0.7 m. high, and 0.7 m. wide, with walls 10–15 cm. in thickness. The rear walls of those aquaria designed for sessile animals are sloped upward at an angle of about 40°, and most of the walls are faced with natural rock. The glazed openings measure 62 by 180 cm., and the glass is 23 mm. thick, set in minium cement in grooves in the masonry with bedding and backing of tow between the masonry on one hand and the cement or glass on the other. The bottom of the aquarium is 1 m. from the floor, and the glass is set back 22 cm. from the face of the masonry. Many panes set in 1882 are still undisturbed. Settling of the walls causes breakage in places. The aquaria are accessible both from front and rear for attendance, a sloping wooden door giving access from the front.

In the passage at the rear a larger tank (1.65 long, 1.15 wide, and 0.9 high, with glass 0.65 by 1.30 m.) projects from the building into the open air. It is sheltered above by a sloping roof of ribbed glass with free access of the air beneath. This aquarium is subject to greater changes of temperature, to access of dust, to more overhead

light, and is less satisfactory than the other aquaria, suffering from excess of growth of green algæ, from unusual outbreaks of *Sarolegnia* and is exposed to extremes of temperature which are deleterious to the animals within, and is therefore instructive as to the relation of these conditions to the maintenance of aquaria.

An aquarium (a gift to the station some years ago), on the inner wall of the passage, measures 1.60 by 0.70 by 0.95, and one at the end of the passage, the largest in the building, is 4 m. long, 2 m. wide, and 1 m. deep. Its walls are of sheet iron lined with cement (2 cm.), but the rust from the iron works through the cement in places. The aquaria are lighted from skylights in the research aquaria room.

Arranged along the west side of the aquarium hall is a row of seven open rectangular aquaria on black marble tables with glass sides. (Pl. XVIII, *B*, and Pl. XX, *A*.) The top of the tables is 0.9 m. from the floor, and the aquaria are all approximately 55 by 80 cm. Their height varies, being 13, 18, 25, and 48 cm. The marble table forms the bottom of the aquaria, and the corners are of angle brass (3 by 3 cm. and 2 mm. thick or 4 by 4 and 3 mm. thick) held from spreading in the case of the two higher types by an adjustable brass band. The glass is 8 mm. in thickness, save in the largest aquaria, where it is 21. The marble, originally polished, has corroded badly under the action of the sea water. In the center of the room is a cement-floor basin, which receives the discharge from the exhibition tanks. It is elliptical in form (3 by 4 m.), with walls 25 cm. thick and 35 cm. high, and a central fountain.

The aquaria in the adjacent experimental room (Pl. XIX, fig. 2) are of a different construction. There are eleven iron tables 67 by 112 cm. with tops of molded glass standing 88 cm. from the floor. The glass is cast so that the sides of the aquaria can be set in grooves in the top, which is perforated by holes for the inlet and outlet. The aquaria all measure 36 by 82 cm. and have plate-glass sides of 11, 15, 20, or 25 cm. in height held in brass angles at the corners and having top clamps of brass across the ends.

Two aquarium tables (Pl. XIX, *A*) of white tile with tops 0.64 by 4 m. and a tile facing on the wall at the rear 64 cm. high and a cement channel at the rear to carry off the waste serve also for movable aquaria of glass. An overhead pipe line with numerous taps supplies the water.

The single-circuit system of circulation is used at Banyuls. The water is pumped by a 9-horsepower petrol motor (system Merlin-Vierzon), which also serves for power for the machine shop. It is connected with a centrifugal pump of phosphor-bronze (type Dumont) with a capacity of 30 cu. m. per hour. The water is drawn through an 8 cm. red-copper sea pipe 30 m. in length carried to the outer side of the promontory and terminating in a masonry basin 1.3 below the

A. GENERAL VIEW FROM THE HILL ABOVE.

From photograph by Doctor Racovitza.

B. INTERIOR OF EXHIBITION ROOM.

From photograph by Doctor Racovitza.

LABORATOIRE ARAGO, BANYULS-SUR-MER.

A. TILE-COVERED AQUARIUM BENCH.

B. EXPERIMENTAL AQUARIA AND WATER FILTER.

EXPERIMENTAL AQUARIUM ROOM AT BANYULS.

surface at the water's edge. To avoid copper salts the first water passed through the pump is not admitted to the reservoir. From the pump the water passes through a 10 cm. main of cast iron to the reservoirs, which have a capacity of 180 and 100 cu. m., respectively. The pump is 6 m. above sea level and the reservoirs 12 and 15.75 m., respectively. The reservoirs are excavated in the solid rock and lined with cement, and are covered with earth to keep the water at a low temperature. The reservoirs are at an elevation of 5 and 9 m., respectively, above the outlets to the aquaria. The daily consumption of water is 40–45 cu. m. in summer and 30 in the colder season.

The circulating system consists of 6 cm. cast-iron pipe made in short lengths of 1 to 2 m. with flush ends, india-rubber gaskets and screw clamps binding together the flanges. Any unit in the system can be removed without disturbing others. The laterals are of 2 cm. soft lead pipe, with terminal cocks of hard rubber. The valves in the mains are of cast iron.

The aquaria are all fed by overhead sprays discharged from a glass pipette at an elevation of a few inches above the surface of the aquarium. No other aerating apparatus is used. The outlets are lead pipes 3 cm. in diameter let into the walls of the masonry tanks for a surface discharge. In the small glass aquaria there are standpipes with surface overflow guarded by a flaring perforated funnel of porcelain. The table aquaria in the exhibition room (Pl. XX, *A*) are fed through curved brass pipes (1.5 cm. diameter) and have vertical standards for discharge. While algæ do not grow in these tanks, delicate animals, such as *Cerianthus*, gorgonians, and pennatulids, thrive, and sponges develop naturally, indicating no marked deleterious effect resulting from the brief exposure of the water to the metal. The waste water from the aquarium hall passes to a concealed tank beneath the entrance steps which is used as an acclimatization basin for animals destined for the aquaria or for shipment.

The aquarium cement used at Banyuls is the customary minium cement and a new "Mastic de Cette," a water and spirit proof odorless cement which retains pliability at low temperature and is reported to be both durable and very effective. It is used extensively in the wine trade for wooden wine vats and possesses the qualities of adhesiveness, impermeability, and elasticity desirable in an aquarium cement.

The aquaria at Banyuls are justly famous for their thriving condition and the perfection with which many forms of animal life grow and reproduce therein. In the aquaria one sees not only the usual array of tunicates, anemones, crabs, lobsters, fishes, mollusks, and starfish, but the delicate and beautiful *Spirographis*, *Cerianthus*, *Veretillum*, pennatulids, gorgonians, *Alcyonium*, and corals such as *Caryophyllum*, *Flabellum*, and *Balanophyllia*, the zoantharian (*Poly-*

thoa) associated with the sponge (*Axinella*), the rare *Bonellia* and other sessile worms of various kinds which are attached to the walls and even the glass of the aquaria. Calcareous seaweeds thrive in the aquaria, and green seaweeds coat the walls and bottoms of the better-lighted tanks.

The purity of the original supply, the carefully regulated temperature in the reservoirs, the single-circuit system of circulation, and the absence, save for the exceptions above noted, of deleterious metals are factors favoring this condition. The iron pipes, especially in dead ends or when water stands in them for some time, accumulate some rust, and this mechanically interferes with the respiration of some animals, as for example the crustaceans, and is also troublesome in culture aquaria for larvæ or pure cultures of algæ, but it seems to have no other deleterious effect upon the life in the aquaria.

The equipment of the research rooms at Banyuls is simple. It includes a U-shaped table in the center of the room 60 and 70 cm. wide and 3.2 m. (inside) long, with small water tank and sink, blackboard, cupboard, and book-shelves and chest of drawers. The rooms are supplied with gas, fresh water, and electric light and are heated by grates or stoves.

The laboratory has a very generous supply of chemicals, reagents, glassware, and the many small items of desk equipment for laboratory work. It possesses twenty microscopes of Nachet and Verick patterns, three with immersion lenses, an ample supply of dissecting lenses and drawing apparatus, five microtomes (two Minot rotary, one Jung sliding, and two of the Dumeige rocking pattern). There are two dark rooms fully equipped for photographic work, one of them located in the atelier above the upper reservoir. This atelier is equipped with an ample laboratory for biological work adjacent to the photographic room, which contains a huge Zeiss micro-photographic apparatus and an equipment of Zeiss protar and planar lenses for the photography of living animals. A unique feature of the equipment is an apparatus whereby animals in polished glass jars lowered into the darkness and even temperature of the reservoir below until they are completely expanded can be brought easily within reach of the camera by means of an elevator.

The resources of the station are also extended by a small animal house, an aviary, and a small greenhouse where experiments with the interesting local land fauna may be conducted if desired. Banyuls lies just within the region of the most northerly extension into Europe of the African land fauna and possesses accordingly a number of forms of unusual interest and rarity for European naturalists.

The collections made in the course of the explorations of the *Roland* remain at Banyuls, affording an abundant stock for examina-

tion or research. A selection of named forms illustrating the local fauna is permanently mounted and placed on exhibition in glazed cases.

The library at Banyuls is second only to that at Naples and Helgoland in its size and completeness. It contains over 5,000 volumes, including about 75 of the leading biological journals and periodicals, bibliographies and reviews of zoological literature, the principal reports of marine explorations, and the leading monographic works and general treatises. There is also a large library of reprints and a small library of selected general literature for idle hours. The library has a card catalogue, is freely accessible, and is pleasantly furnished. It contains the personal library of its founder and of Professor Pruvot and Doctor Racovitza, the present editors and proprietors of the "Archives de Zoologie expérimentale." A list of the more important serials, etc., in the library will be found in the "Archives" for 1901, and of the monographs and individual treatises in subsequent volumes.

The marine equipment of the Banyuls station is exceptionally complete and is maintained in a very high state of efficiency. In addition to a flotilla of five small boats, a small sail boat, and a 6 m. motor boat, there is a wooden steamer, the *Roland* (Pl. XX, *B*), the most completely equipped small steamer for biological work to be found among the stations of Europe. The *Roland* is 22.22 m. long, 4.65 m. wide, and has a draft of 2.1 m. aft. She is a stout wooden steamer of 118 tons gross, with a single mast forward and a full equipment of sails, deck houses forward and aft, and deck space forward and astern for landing of trawls, etc. The wheel is upon the forward deck house (which contains the galley) in a commanding position for maneuvering the boat and tackle. On a table amidships, in front of the after cabin, is the sounding machine, with its one-half horsepower engine. She has a 75-horsepower compound condensing engine, with distilling apparatus for boiler water, a 3-horsepower dynamo for electric light for lighting the ship and for pelagic towing at night, a 9-horsepower pump which provides also for a circulating system in storage tanks for collections on deck. The bunkers can receive 12 tons of coal, sufficient for eighty hours' continuous steaming at 7 knots per hour.

There is a steam winch of 10 horsepower forward, with supplementary hand winch for reeling up the cable or for light work. In summer 1,000 m. of 12 mm. galvanized steel cable is carried on the reel. In winter only 500 m. is used. For heavy work or in heavy weather the cable is passed aft between rollers, while in quiet weather or for light work the tackle is handled forward.

The sounding machine, made in the shops of the laboratory, carries 2,000 m. of 0.7 mm. steel piano wire. The drum also carries

800 or 1,500 m. of 4 mm. galvanized steel cable for plankton and hydrographic work. The boat is equipped with the usual dredges, nets, and seines, with otter trawl and beam trawl, coral tangles, and a number of large plankton nets of several types for pelagic fishing. The hydrographic equipment includes two reversing thermometers, bottom samplers of various types, and two water bottles (Richard).

The rear cabin (3 by 3 m.) serves as a laboratory and is provided with folding tables at the windows, a center table, and convenient reagent lockers, shelving, and racks. The boat is remarkable for the completeness with which all available space is utilized and for the compactness of her fittings. She has ample lockers for glassware, reagents, and collections, the space along the gunwales being utilized for a bank of thin cupboards for glassware, etc., and a conveniently located reagent case is placed on the rear face of the cabin near the sorting deck. Racks for collecting jars are arranged along the port side. Refrigerator, dark room, and tackle room are placed below deck. Berths for fifteen persons are provided, six forward in the forecastle, two for engineer and captain aft of the engine room, two small separate cabins below, each for two persons, and three folding berths aft on deck.

The station also has a scaphander with pump and hose for explorations to a depth of 40 m. It has proved to be an important adjunct of the station in exploring the coasts, and especially the grottoes, which are numerous along the limestone cliffs of the region.

The machine shop of the Banyuls station is the best equipped one found in connection with any European station. It is fitted for metal, wood, and electrical work and contains a forge and small foundry and a considerable assortment of machine tools, such as power lathes, shaper, planer, drills, dynamo of 40 amperes, and accumulator. M. David and his apprentices do in this shop practically all of the construction work in connection with the station and its boat, building everything from museum cases to sounding machines.

The two papers of Pruvot (1894, 1895) give a very adequate account of the local oceanographic conditions and of the distribution of the local fauna. The shores in the region are predominantly rocky, of schists and limestones, with a few sandy beaches. The shore line is everywhere marked by a "trottoir" or platform of calcareous algæ. The shore falls away rather abruptly to depths of 30 to 50 m., but thence a great plateau of mud and sand, 50 to 110 m., slopes seaward for a distance of 25 to 39 km. before sinking abruptly into several sunken valleys whose sides descend suddenly to a depth of 800 m. There is a narrow *Laminaria* and a wide *Lithothamnion* zone, and scattered rocky "banks" are interspersed in the plateau.

A. TABLE AQUARIUM.

B. THE "PRINCE ROLAND."

From photograph by Mme. Pages.

BANYULS STATION.

The flora and fauna are much like those at Marseille, Villefranche, Monaco, and Naples. The pelagic fauna is rich, especially in the deeper waters or after a spell of "mistral" weather. The shore and bottom life is rich and varied. The lists published by Pruvot of common species include many choice treasures for the naturalist, *Cerianthus, Bonellia, Polygordius, Antedon* (1,500 in one haul of the dredge), *Amphioxus, Corallium, Sepia, Brissopsis, Neomenia*, corals, and brachiopods in the deeper waters. A large territory has been explored and mapped adjacent to Banyuls and its fauna fully recorded. In general, temperatures and salinities are similar to those at Monaco, and as elsewhere in the Mediterranean the tides are insignificant—0.4 to 0.6 m.

Literature: Lacaze-Duthiers (1874, 1877, 1881, 1881a, 1891, 1895, 1898), Dean (1894), Francotte (1907), Gruvel (1898), Sand (1897), Pruvot (1894, 1895, 1897, 1901), Houssay (1893).

BIOLOGICAL STATION OF ARCACHON, ARCACHON (GIRONDE), FRANCE.

Director, Prof. Felix Jolyet, professor of physiology, École de Médecine, Université, Bordeaux.

Assistant director, Dr. J. Sellier, Chef des Travaux, Laboratoire de Physiologie, École de Médecine, Université, Bordeaux.

Preparator, M. Delaunay.

In addition a keeper and one machinist and fisherman.

Telegraph address: Aquarium, Arcachon.

The laboratory at Arcachon enjoys the distinction of being one of the oldest in Europe and one of the first to open its doors gratuitously to the scientific world for the purposes of research. It is all the more remarkable in its origin and history, since it originated as the private enterprise of a local scientific society, Société Scientifique d'Arcachon, in 1863, having for its avowed objects the aiding of the study, the advancement and popularization of the natural sciences, and the development of aquiculture. To this end it set about to organize and maintain a museum, library, and an aquarium with laboratories for study and research in biological science.

Prof. Paul Bert, the noted physiologist, and the conchologist, Professor Fischer, were active in aid and counsel to the infant enterprise. In 1866 the society undertook the somewhat ambitious task of conducting an International Exposition of Fisheries and Aquiculture at Arcachon and achieved a considerable success with 588 exhibits in the building erected for the purpose. The exposition building and the aquarium became the permanent plant of the station and are still in use, while the exhibits furnished the beginning of the museum and library. The enterprise left the society, however, heavily burdened with a debt of 45,000 francs, loaned by members

and friends of the enterprise, under which it labored till 1896, when, by agreement, it was largely reduced by cancellation and the payment of the balance arranged for in yearly allotments, terminating in 1906.

In the meantime the society voted, in 1867, to proceed with the construction of a special laboratory building, but the war of 1870 and its consequences embarrassed the enterprise for twelve years, so that the laboratory was not actually begun until 1883. The establishment of a faculty of medicine and pharmacy at Bordeaux created the demand for a marine laboratory for the use of its professors and students which had exceeded the then meager facilities at Arcachon. The society, still adhering with great pertinacity to its autonomy and independence and final control of the station, placed its resources at the disposition of the university and endeavored to increase its facilities by the erection of the special laboratory building. A lottery designed to provide the funds yielded only 7,359 francs, a sum with supplementary aid from the society sufficient to erect only four rooms of the projected building. It was not until 1902 that the building with eight private laboratories and five chambers was completed.

The enterprise at Arcachon has from the beginning been a local one, controlled by a local society composed of public spirited residents and scientific men of Bordeaux and vicinity. Prominent among those who have given largely of their time and effort to the station are M. Lamargue de Plaisence, the mayor of the village, and founder of the society, Dr. G. Hameau, president of the society for many years, and his son, Dr. A. Hameau, the present president, and Dr. F. Lalesque, its former president. The first formal director of the station, M. E. Durègne, an engineer, served from 1880 to 1886, when he was succeeded by Dr. H. Viallanes, who served until his death in 1894, being succeeded by the present director, Prof. F. Jolyet, professor of physiology in the medical school at Bordeaux.

The society at Arcachon consists of about 160 members with a council of administration composed at present exclusively of local representatives. This council appoints the director who has charge of the laboratories and aquaria. Officers of the society conduct the business and have charge of the library, aquarium, and museum. The connection with the University of Bordeaux is purely formal, insuring to the faculty and students of the university the privileges of the station, but not to the exclusion of others. The university has no formal control over the station and contributes nothing to its support beyond its membership fees. The scientific staff, consisting at present exclusively of members of the department of physiology of the university, receive no salary from the station, but enjoy its privileges for their researches.

The station has no endowment, but depends entirely for its support upon the fees of the members of the society and small annual grants from governmental and other sources. Its budget is as follows:

Receipts and expenditures of the biological station of Arcachon, 1908.

	Francs.
Receipts:	
Memberships	3,200
Subventions—	
Ministry of public instruction	500
Ministry of agriculture	200
City of Arcachon	2,000
French Association for Advancement of Science	300
Department of Gironde	500
Admissions to aquarium and museum	1,400
Sales	5,000
Miscellaneous	5,000
Total	18,000
Expenses:	
Loan	600
Office and service	2,400
Buildings and materials	7,000
Laboratories	2,000
Aquarium and pisciculture	1,300
Printing	1,300
Museum and library	600
Upkeep and miscellaneous	2,800
Total	18,000

The support of the station is most meager in view of the facilities already offered and the possibilities which the location affords for service to instruction and research. The exceptional opportunities for scientific investigation along zoological and oceanographic lines as related to the important fisheries of the Gulf of Gascony and to the manifold problems of ostreaculture as yet await development.

The small annual stipend received from the ministry of agriculture does not suffice for any systematic investigation along economic lines and indeed research in such lines is wholly voluntary on the part of the station. It has no obligatory relations to the economic or scientific interests of the fisheries. Professor Sauvageau has contributed in this field an important memoir (1907) upon the "greening" of the oysters of Marennes by a blue diatom, and other investigations of interest to the fisheries have been carried on in its laboratories.

The Arcachon station, in so far as the laboratories are concerned, is purely a research station, frequented mainly by professors from the universities of France, with occasional visits from foreigners. No effort is made to carry out any special programme of research,

each individual following his own independent work. Owing to the relation of the station to the department of physiology at Bordeaux, the equipment and work of the station is largely in physiological lines.

The station is open throughout the whole year, but the aquaria are not maintained during the winter months and only a few of the rooms are provided with heat. The station has ten private laboratories, some of which may accommodate two persons. The facilities of the station are offered without charge to French and foreign savants alike. About a dozen investigators avail themselves of this privilege annually. Application should be made in advance to the director or to the president of the society, stating the position and qualifications of the applicant and giving the list of instruments, glassware, chemicals, etc., necessary for the intended research. In so far as the limited budget permits, provision will be made of the necessary equipment. The aquarium, which is a source of income to the station, has first claim upon the material, but its abundance in general is such that no difficulty arises from this source.

The station also provides simply furnished lodgings, ten chambers in all, for workers at the station, at a modest charge of 7 francs per month for service; light and heat at cost. A copy of the rules governing workers at the station is sent on request.

Investigators are expected to furnish their own microscopes, but a microtome is to be had at the station. A résumé of all work carried on or completed at the station, wherever published, is to be furnished to the director for insertion in the "Travaux" of the station and acknowledgment of the utilization of the privileges of the station is expected.

The station renders a service to the popularization of science by maintaining an aquarium during the summer months and a museum of local natural history and antiquities and conducting occasional popular lectures on biological subjects. It also conducts a supply department, furnishing living material and fresh sea water for aquaria, making a specialty of *Hippocampus*, which abounds in the "Bassin." Living and preserved material for laboratory use is also supplied. A price list of material is issued.

From 1895 to 1908 the station issued somewhat irregularly a small publication bearing the title "Société Scientifique d'Arcachon. Station Bioloique. Travaux des Laboratoires," the eleventh "Année" appearing in 1908. In 1908 the size of the publication was considerably increased, and in 1909 the title simplified to "Bulletin de la Station Biologique d'Arcachon." Much of the scientific work done at the station appears, however, in publications of the scientific society at Bordeaux and in journals elsewhere. A "Compt-Rendu Administratif" is also issued annually.

Arcachon is the most frequented of the local seaside resorts on the west coast of France, 56 kilometers southwest of Bordeaux, reached in one to two hours by frequent trains from that city. It is situated on the south shore of the Bassin d'Arcachon not far from the entrance of the great lagoon of 50 miles circumference and 60 square miles area, containing the most extensive oyster parks in France.

The station lies on the water front a few minutes walk from the railway depot, on the Rue de Debarcadére opposite the Casino. It is entered through the grounds of the Administration des Ponts et Chaussées from the Boulevard de la Plage. The plant, located in grounds containing 1,875 sq. m., consists of a group of buildings in part erected for the fisheries exhibition held in Arcachon in 1866, with accretions of later years.

The main building is a plain square structure of wood (14 by 15 m.), the "Musée-Aquarium," containing on the first floor a chemical laboratory (4 by 6 m.) with hood, cement table, and very simple fittings, a biological laboratory (4.5 by 5.5 m.), four furnished chambers for workers at the station and the corrider leading to the aquarium which lies in an annexed section at the rear (5 by 30 m.). The keepers' quarters occupy part of the ground floor of the main section and an adjoining part of the building. On the second floor of the main building are the library and museum.

The laboratories, storerooms, and shops are found at the rear of the main building, facing the Bassin at a distance of about 30 m. from the high-tide line and an elevation of about 2 m. above high tide. The building consists of two parts, a brick portion (3.4 by 36 m.) fronting the sea and an older wooden section (10.8 by 36 m.) at its rear. The brick building consists of a central section (4.1 by 14 m.) two stories in height with two wings (3.4 by 11 m.) of one story. The central section contains three rooms, the office and laboratory of the director and the laboratory of the assistant director, each of about 20 sq. m., while above are five chambers. The wings provide five other laboratories, four of about 15 sq. m. and a fifth 3.4 by 7 m. The larger laboratory is especially equipped for botanical work and is provided with three floor tanks of reenforced concrete (1.45 m. long, 0.7 m. wide, and 0.6 m. deep, with walls 6 cm. thick), a cement sink and sink table (0.5 m. wide, 3 m. long, 0.86 m. above floor with back 0.6 m. high) and a cement table (0.5 by 2.5 m. and 8 cm. thick). One of the laboratories is equipped for work in physiological chemistry, and three for work in physiology, while the remaining three serve for zoological investigations. One of the physiological laboratories is equipped with floor tanks similar to those of the botanical laboratories. Salt water is provided in all the rooms, but there is no further provision for permanent aquaria attached to the circulating system. The rooms are also provided with fresh water, gas, and a very simple equipment of a

peripheral shelf for work table, shelving, cupboards, etc. The rooms are abundantly lighted by the large north windows and are all entered separately from the wooden building to the rear. The two larger laboratories in the Museum building, with south exposure, are heated and may be used for work in the winter. The wooden building to the rear of the laboratory consists also of a central section and two wings, the former of two stories, containing above the reservoir and below a tool shop and dissecting room (4.4 by 7.5 m.) with dark room (2 by 2.4 m.) in one corner, and the engine room and store room (3.8 by 7 m.).

The two wings are open along their entire southern faces and serve as storerooms for tackle and fishing apparatus, while in their cement floors are sunk several large basins for the storage of material destined for the aquaria, for the laboratories, or the supply department. There are three of these tanks in the east wing each 2.2 m. wide and 10.2 long, with walls of cement 15 cm. (in the deepest 25) in thickness, and 30, 55, and 85 cm. in depth, respectively. In the west wing there are but two basins, one 2.25 by 10.2 m. and 45 cm. in depth, with walls 15 cm., and an incomplete central partition 6 cm. thick, the other 2.5 by 10.2 m. and 85 cm. deep with walls 25 cm. thick. These basins with their great surface exposure serve admirably for storage of fish and invertebrates and even of dolphins, which have been kept here in confinement for several months.

The equipment of the research laboratories of the station is intimately associated with that of the physiological laboratory at the University of Bordeaux, from which apparatus, chemicals, etc., are supplied for the time according to the needs of the investigators. The laboratory possesses a small equipment of physiological apparatus, not of recent origin, mainly for investigations on the physiology of nerves, muscles, circulation, and respiration. It includes a centrifuge and water motor, a Marey and Foucault registering apparatus, several myographs, cardiographs, and kymographs and the simpler electrical apparatus for recording physiological phenomena with a microscope for the accompanying photography. In the chemical laboratory there are several types of mercury pumps and other apparatus for analysis of gases, of water, and blood. There is also a simple equipment for bacteriological work consisting of an autoclave and ovens of Gay-Lussac and Roux.

The library of the station contains about 2,000 volumes, including a number of serials, early expeditions, and general works of French origin and a number of foreign exchanges as well as miscellaneous works of local interest. The collections include an exhibit of local archeology and antiquities, of the apparatus and methods used in ostreaculture, with models of oyster parks and photographs illustrating the various steps in the culture and marketing of the oyster. There is also a collection of oysters of the world, and one of the local fauna

and flora with maps and plaster models of the "Bassin" made largely in connection with the exposition of 1866.

The pumping plant of the station consists of a steel windmill supplemented by a steam pump of 2.5 horsepower. The water is drawn through a 6 cm. lead pipe and carried about 100 m. to a receiving tank near low-tide level. From the brass pump the water is carried in a 5 cm. copper pipe to the reservoir at an elevation of 3.5 m. The reservoir is of wood (3.3 by 7.8 by 0.8 m. in depth) with 3 mm. lead lining. The water is distributed from the reservoir to the aquaria and laboratories in lead mains of 6, 5, and 4 cm. and lead laterals 2.5 cm. carried to the bottom of the aquaria. The cocks and valves are of brass or brass matrix and wooden plunger.

The exhibition aquaria are arranged along one side of a long dark corridor (3 by 30 m.) at the rear of the museum. There are eighteen tanks 1.2 m. long, 1 m. wide, and 0.8 m. high, of about 1 cu. m. capacity, and four of two units each 2.4 m. long. The walls are of mortised slabs of gray marble 6 cm. thick, with partitions 8 cm. thick, held together with iron bands and joined in front to a cement frame with the bottom rail 6 cm. and the verticals 8 cm. wide projecting 5 cm. beyond the glass which is set in litharge in channels in the cement, with buffers of rubber. The openings are all 65 by 112 cm. and the glass for the small tanks is 0.8 by 1.2 m., in the large ones 0.8 by 2.05 m. and 15 or 20 c. m. in thickness. The longer panes have a central brace on the outside.

The water is used but once in the aquaria and owing to the considerable turbidity caused by the strong tidal currents is allowed to settle in the reservoir before using. There is no system of aeration nor of constant circulation. The water is renewed in each aquarium in the morning or oftener if the heat is considerable. It is possible, if the aquaria are not overpopulated, thus to keep the animals in fair condition with an exhibit of the littoral and bottom fauna of the Bassin.

The field equipment of the station consists of a new motor launch, the *Navicula*, 9.5 m. long, 2.1 m. wide, and draft of 0.7 m. with a 12-horsepower benzine motor of the automobile type (System Couach-Arcachon), of light construction with auxiliary sails adapted for work in the Bassin. There is also a pinnace, the *Hippocampe*, of 8 m. with sails. The station possesses the usual supply of dredges, nets, seines, trawls, and plankton nets of simple type, also a reversing thermometer, but no expensive equipment for work at sea or in deep water or for hydrographic investigations.

The environmental conditions at Arcachon present an exceptionally fine example of a tide-swept lagoon in open communication with the ocean, of wide extent (60 sq. miles), varying in depth down to 27 m. with numerous branching channels and wide areas (two-thirds

of the Bassin), left bare at low tide. The considerable movement of water with the changing tides, estimated at an average of 27,000,000,000 cubic meters, conduces to the growth of an abundant bottom fauna in the channels and a rich plankton, as is indicated not only by the collections of the station but also in a very conclusive manner by the extensive fisheries and oyster parks at Arcachon. The amplitude of the tides varies from about 2 m. at neap to 4 m. at spring.

The local fauna and flora are those characteristic of sandy shores and lagoons, with that of the mud flats found near the head of the lagoon and the few brackish waters near the entrance of the Leyre, a small stream which joins the Bassin. Although not rich in the number of easily obtained species, the quantity of material available is very considerable at Arcachon. *Verticillia*, *Sepia*, *Aplysia*, *Asterias*, *Hippocampus*, *Scyllium*, *Torpedo*, and *Trygon* abound, and *Amphioxus* also occurs. Of echinoderms 26, of crustacea 71, of mollusks 302 species have been recorded at Arcachon. The oyster parks afford an abundance of many of the smaller sessile tunicates, hydroids, and annelids.

The sardine fisheries, recently developed to a large extent, and the 40 to 50 steam trawlers which make their headquarters at Arcachon add also to the biological and ichthyological resources of the station. The fishing companies often render courtesies to the station in furnishing material or opportunities for collection.

An annex to the Arcachon station has been established at Guethary (Basses-Pyrénées) near Biarritz, about four hours by train from Bordeaux, located on a rocky coast with its characteristic and richer fauna. The building is a simple stone structure of one room (3.54 by 4.69 m.) near the water's edge with simple furnishings for a field laboratory. A local fisherman serves as collector as needed.

Literature: Compte Rendu Administratif (1901–1908), Dean (1894), Sand (1897), Durègne (1886, 1888), Lalesque (1900), Jolyet et Lalesque (1904).

LABORATORY OF MARINE ZOOLOGY AND PHYSIOLOGY AT CONCARNEAU (FINISTÈRE).

Director, L. F. Henneguy, Professeur d'Embryogénie comparée, Collège de France, Paris.

Assistant director, Dr. Fabre-Domergue, inspecteur-général des Pêches Maritimes, Magazin Central de la Marine; 64 Quai Debilly, Paris. Residence, 208 Boulevard Raspail, Paris.

Resident naturalist in charge of the station, Dr. J. Guérin-Ganivet, naturaliste attaché au service scientifique des pêches au ministère de la marine, Laboratoire Maritime, Concarneau.

In addition, a keeper, a machinist, and a servant.

Telegraph address: Laboratoire, Concarneau.

The laboratory at Concarneau enjoys the unique distinction of being the first maritime laboratory founded in Europe. While it is true, as Sand (1897) has pointed out in the case of the Belgian laboratory at Ostend opened in 1843 by Prof. P. J. Van Beneden, that it is antedated by other enterprises, these have in all cases been of a temporary character, partaking rather of the nature of biological seaside excursions or summer laboratories for a few months of the year at the most, without permanent building or equipment.

In 1859 Prof. J. J. Coste, the French naturalist, opened at Concarneau this institution designed as a permanent station of biological research at the seaside. He was succeeded as director by Prof. Charles Robin, who shared the directorship with Prof. Georges Pouchet, of the Museum of Natural History in Paris. On the death of Professor Robin, in 1885, Professor Pouchet became sole director. Associated with him as assistant directors were Doctor Hermann, and later Doctor Chabry. Upon the death of Professor Pouchet in 1894 the laboratory passed to the hands of a council of directors named by the professors in the Collège de France.

The station at Concarneau is at present an adjunct to the Collège de France and is controlled by an administrative council, nominally known as "directeurs," consisting at present of Prof. Arsène d'Arsonval (medicine), L. Ranvier (general anatomy), E. Gley (physiology), and Henneguy (comparative embryology), all connected with that institution. This council nominates the staff of the station for confirmation by the minister of public instruction. The director is responsible to the council and minister and makes an annual report to the minister upon the progress and activities of the station. The entire conduct of the station is in his hands. At present both the director and assistant director are residents of Paris, and the immediate conduct of the station is in the efficient charge of the resident naturalist, Dr. Guérin-Ganivet, an attaché of the fisheries service.

The budget of the station is derived from two sources, an annual grant of 6,000 francs from the ministry of public instruction and one of 3,500 francs from the ministry of the marine. In addition a sum of 7,000 francs for salaries of the scientific staff is paid annually from other budgets, and the support of the fisheries inspection boat *Petrel* which the station employs in its field work comes entirely from the budget of the marine service. The income of the station is allotted as follows:

	Francs.
Office expenses	500
Library	1,000
Scientific research	3,000
Upkeep of building and equipment	3,000
Total	7,500

The station is maintained at present purely as a research institution, giving no instruction of advanced or elementary nature and maintaining no popular features such as public aquarium or general lectures. Its facilities are open without charge to all competent investigators, French or foreign alike, in so far as the room and limited budget of the station permit. There are 8 investigators' rooms, accommodating one or at the most two persons each. Applications for admission should be made in advance to the director, stating the time for which a table is desired and the material desired for research. Investigators should provide their own microscopes. They are supplied with the material for research or the facilities for collection, with the usual chemicals and reagents, are permitted to use the aquaria and dark room, library, and the other facilities of the station. The only charges made are those for containers and packing for material removed from the station.

The station also supplies gratuitously to investigators and educational institutions living animals and sea water for aquaria, and preserved material prepared by simpler methods, for research and instruction; the cost of containers, packing, and shipping being borne by the receiver. No list of material supplied has been issued. Collecting for museums and educational institutions is freely permitted, but not for commercial purposes.

In consequence of the annual grant from the ministry of the marine the station has assumed the obligation of preparing upon request of the minister special reports upon questions of the fisheries. The location of the station at a great center of the sardine, oyster, and lobster fisheries places it in an advantageous position to render assistance where scientific investigation is needed in the regulation and development of these industries.

The resident naturalist also carries on continuous investigations along lines of more or less direct relation to the fisheries. The subjects under investigation at present are the distribution and œcology of the edible mollusks of the region and the hatching and rearing of young sea bass (*Labrax lupus*) and of the lobster and crayfish (*Palinurus*).

The station has no other programme of oceanographic or biological research. The investigations conducted at the station in the past have been numerous and important, appearing in many French journals, especially in earlier years in the "Journal de l'Anatomie et de la Physiologie," edited by its former directors, Robin and Pouchet. At present the reprints of work done here are issued in a series entitled "Travaux Scientifiques du Laboratoire de Zoologie et de Physiologie maritime de Concarneau" (1909+), and a new serial to contain the investigations at the station is planned to appear in the near future.

A. INTERIOR OF PHOTOGRAPHIC STUDIO, BANYULS.

From photograph by Doctor Racovitza.

B. VIVIER PLANNED FOR LOBSTER CULTURE. LABORATOIRE MARITIME, CONCARNEAU.

Concarneau is a quaint fishing town on the south coast of Brittany, much frequented by artists and tourists and full of interest to the visiting naturalist. It is reached in thirteen hours from Paris or in five hours from Roscoff, via Carhaix. The station is located immediately upon the rocky shore in the Ville Ouverte, across the channel from the ancient walled town, on the western side of the mouth of the harbor, between the small cove Kersos and the Baie de la Forêt. The building fronts on the Place de la Croix near the Halle a la Criée, where the daily auctions of the catches of the fishermen are held. It stands in restricted grounds of about 2,250 sq. m., including a small garden in front of the building with the residence of the assistant director attached thereto, and the large vivier or lobster basin on its seaward side. The building is a plain structure (8.75 by 30 m.) of nearly rectangular form, with massive granite walls. Its main axis runs nearly east and west and the working laboratories with one exception have a south exposure. The building stands immediately upon the water front and its basement is but 1 m. above ordinary high tide. It contains two floors; the upper, entered from the street, contains the laboratories and library, and the lower, the aquaria and storerooms.

The entrance leads directly into the central laboratory room (7.77 by 17.2 m.) on the main floor, from which open the library, dark room, tool shop, and the smaller private laboratories. About its walls are the cabinets for the collections, and the reagent and chemical cupboards, table for paraffin oven and blast lamp, and a Fabre-Domergue rotation apparatus with hot-air motor for rearing larvæ. There are also three large dissecting tables (1 by 2 by 0.8 m. high) and a cement sink. Adjacent to this are the library (3.25 by 5.4 m.), the dark room (1.25 by 3.3 m.), the tool shop, and from it open three small laboratories and the corridor leading to four others and to the well-stocked glassware room (3.3 by 4.35 m.). The private laboratories are 2.75 m. in length and from 2.1 to 3.65 m. in width, containing from 4 to 10 sq. m. of floor space. They are all well lighted by single windows, and in 1909 were in part renovated and refinished in excellent fashion. They are supplied with fresh water and gas, and have in some cases a work table (0.6 by 1.4 m.) facing the window, a sink of glazed fire clay and table of white tile, shelving of plate glass, and an abundance of compactly and conveniently arranged cupboards and cases of drawers. Sea water and aquaria with circulation are provided only in the basement. One of the rooms is equipped with a chemical table and is designed especially for chemical work. The central laboratory and one of the private laboratories are heated by stoves for work in winter.

In the basement are located the aquarium room (7 by 9 m.) and three large granite reservoirs, the machine room and large storerooms, used in part at least for commercial purposes.

The pumping plant consists of a 4-horsepower Durand gas (or petrol) motor with a brass horizontal plunger pump (Echirion). The sea pipe is about 8 m. in length and is of galvanized iron (6 cm. outside diameter) terminating in a perforated nozzle in one of the granite basins of the vivier. The mains are of 6 cm. lead pipe, the laterals of 4 cm. Cocks and valves are of brass. The aquaria are fed by overhead spray and have vertical standpipes with surface outflow.

The water is delivered from the pump into the communicating reservoirs, three in number, located in the basement at an elevation of 2 m. above the floor. These reservoirs have walls of granite 18 cm. thick laid up in cement, are of irregular form, and have a total capacity of about 60 cu. m. There is but little seepage through their walls. The pumping plant is supplemented by an "aeromotor" windmill, with brass plunger pump, drawing its water from the basin of the vivier.

The aquarium room (7 by 9 m.) is dimly lighted by two windows, in each of which are placed two of the aquaria. Upon the floor is a floor basin (2 by 3.2 m. and 0.5 m. in depth) with walls of granite slabs 14 cm. thick. Along the southern and western walls there is a peripheral floor tank (0.9 wide and 0.4 m. deep with cement walls 13 cm. thick) divided by adjustable partitions of wood or by granite walls. In this room are located also seven aquaria (Pl. XXII, *A*), all with copper frames set on bases made of marble slabs 3 cm. thick. There are two 1 by 0.6 m. and 0.2 m. deep, two 1 by 0.4 and 0.4 m. deep, two 1.25 by 0.7 and 0.4 m. deep, and one 0.5 by 0.5 and 0.2 m. deep. All have plate-glass sides 1 cm. thick.

The aquarium room is also provided with a Fabre-Domergue hatching apparatus equipped with small hot-air motor, driving six rotators, three in glass jars 35 cm. wide and 35 cm. deep, and three in a rectangular aquarium 7.5 by 0.4 m. and 0.4 m. deep, with wooden base and copper frame with plate-glass sides.

The Concarneau station is well equipped with glass ware, chemicals and reagents for morphological work. It has four microscopes, one of which is a high-grade Zeiss, and two Zeiss-Greenough instruments. There is also a Minot rotary microtome and several paraffin ovens. There is little equipment for physiological or chemical work, and as yet no adequate supply of aquaria or special provision for the purity of the sea water for experimental work.

The laboratory has a special aquarium with white background and large horizontal and vertical stands for photographing living animals, and a dark room for photographic work.

The station has a small collection of the local fauna, principally mollusks and fishes. The library contains about 2,000 volumes, mainly zoological, including especially works on fishes and fish

A. WALL AQUARIA.

B. FABRE-DOMERGUE ROTATOR FOR FISH HATCHING.

LABORATOIRE MARITIME, CONCARNEAU.

culture and a number of French serials and reports of expeditions, the *Challenger* reports, etc.

The marine equipment of the station itself includes a wooden motor boat, the *Sardine*, of 11 tons, 12 m. long, 1.9 m. wide, with a draft of 1.8 m. It has a 25-horsepower petrol motor, and is equipped also with mast and sail. It is provided with dredges for bottom collecting and nets for pelagic fishing. There is also a small sailboat, the *Coste*, of 1½ tons, 4.7 m. long and 1.7 m. wide, and two small boats for shore and harbor work, with the usual equipment of trawls, dredges, seines, nets, lobster and fish traps, and baskets.

The station is fortunate in having the use for work at sea and in deep water of the fisheries inspection boat *Petrel*, with headquarters at Concarneau. This is a steel steamer of 120 tons, schooner-rigged, with two masts and 400-horsepower engines, carrying a captain and crew of eight men and having berths for four scientists. It has no special laboratory. There is a steam winch of 1,500 kilos for dredging, etc., carrying 2,800 m. of galvanized steel cable 12 mm. in diameter. It is equipped with a Belloc sounding machine, with 1,000 meters of sounding wire and a Leger bottom sampler, Negretti-Zambra reversing thermometers, Richard water bottle, the large Richard plankton net, otter trawl and nets and fish traps.

A unique feature of the equipment of the Concarneau station is the large vivier, a group of large culture basins (Pl. XXI, *B*) extending seaward from the south face of the laboratory. The shore has been excavated and the sea front of the basin extends to low-tide level. The vivier is surrounded by a massive outer wall of granite whose lower part is 1.8 m. thick and 4 m. high. Upon this rises a protecting wall 2 to 2.4 m. above high-water level, to prevent damage to the basins by the storms to which it is exposed. The vivier, which contains about 1,350 sq. m., is subdivided into eight basins of different sizes separated by partition walls of granite 0.9 to 1.4 m. wide, whose tops serve as walks about the vivier. The open spaces are in part sheltered from the direct rays of the sun by loosely laid wooden covers. The vivier connects directly with the sea by a gate adjusted by lever and screw to regulate the inflow and outflow of tidal waters. Gratings in the partition walls permit the free circulation of the water between the several basins of the vivier. The basins were originally intended for use in pisciculture, and especially in lobster culture. They serve at present as storage basins for fish used in obtaining ova for hatching experiments and for storage of material obtained on collecting expeditions. A very considerable quantity of the normal shore fauna develops upon the rocky bottom and walls of these basins and is thus readily accessible under all conditions of weather to the naturalists at the station.

The station also has under its control on the Isles Glénau, three hours' journey by sea, a now dismantled fort which provides a field laboratory for naturalists visiting the rich collecting fields in its neighborhood.

The coast at Concarneau is rocky and much broken into fissures, clefts, scattered islets, and submerged rocks. It is constituted of a coarse diorite and of schists, with occasional stretches of white siliceous sands. The adjacent ocean bottom is generally rocky, often covered with the débris of calcareous algæ (*Lithothamnion*). Mud and sandy mud bottoms are rare. Depths in the Bay of Concarneau are 12 to 15 m. on the average, while between the coast and the Isle de Glénau, 10 miles to sea, depths of 25 to 30 m. are reached, diversified by many stretches of rocky bottom.

By virtue of its relation to the Gulf Stream the climate at Concarneau in winter is mild, the temperature rarely falling to freezing point, but in summer it rises to 32° to 35° C. The mean temperature of the sea water varies from 9° C. in December to 18° in July, and the salinity is practically that of normal Atlantic water. The location of the station on the open coast, the relative absence of sewage contamination, and the extensive movement of tidal waters makes available at Concarneau water of exceptional purity.

The character of the bottom and shores and the great tides insure a rich fauna and flora, especially that of the sessile or attached type while the sardine fisheries are proofs of the richness of the pelagic life. The tides, with a great amplitude at spring, make accessible to the shore collector wide stretches of rich collecting grounds abounding in rocks, beds of algæ, and tide pools. The fauna accessible at Concarneau is that characteristic of rocky bottoms. It is especially rich in cœlenterates, mollusks, gephyreans, bryozoans, and crustaceans. The algæ beds on the Isle de Glénau are reputed to be the richest on the coasts of France. The extensive fisheries for lobsters, crayfish (*Palinurus*), and sardines of the port add to the biological resources of the station.

Literature: Pouchet (1883, 1887, 1888, 1890, 1891), Francotte (1907), Guérin-Ganivet et Legendre (1909).

BIOLOGICAL STATION OF ROSCOFF (FINISTÈRE), FRANCE.

(Laboratoire Lacaze-Duthiers.)

Director, Yves Delage, professeur de zoologie à la faculté des sciences de l'Université de Paris. Laboratoire de Zoologie, La Sorbonne, Paris. At Roscoff, May–September.

Assistant director, Dr. E. Hérouard, maître de conférences, Laboratoire de Zoologie, La Sorbonne, Paris.

Preparators, M. F. Vlès and A. de Beauchamp, Laboratoire de Zoologie, La Sorbonne, Paris.

Naturalist, M. C. Schlegel, attaché au service scientifique des pêches maritimes, Roscoff.

Assistant preparator, M. H. Cozie, Roscoff.

Telegraph address: Laboratoire, Roscoff.

In addition, a captain, machinist, sailor, and a housekeeper.

"On chercherait en vain, je crois, sur nos côtes une position plus favorable."—Lacaze-Duthiers, 1877.

Founded in 1872 on a subsidy of 3,000 francs per annum from the ministry of public instruction by Henri Lacaze-Duthiers, professor at the Sorbonne, one of the most famous of the zoologists of France in the past century, noted for his wide knowledge of the fauna of the several coasts of France and northern Africa and for his many monographs on marine animals, the station at Roscoff was at first intended only to be a temporary affair, a stopping place for an itinerant station which should move about the coasts of France. The difficulties and limitations of this plan and the marvelous resources of the location at Roscoff led the founder to advocate a permanent station at that place. Accordingly, in 1876 the rented quarters were abandoned and a house with a large garden near the water front vis à vis to the Île de Batz, which forms a protection against storms from the north, was purchased by the ministry for the station, and the institution was designated as the "Laboratoire de zoologie expérimentale."

The director was fortunate in securing early in the history of the station the services of Ch. Marty, a naturalist fisherman, whose skill as collector, wide knowledge of the local fauna, and genial character, endeared him to a generation of investigators.

In 1881 the station was formally annexed to the Sorbonne, and in the interval between 1878 and 1881 its equipment increased by the gift of a boat, the *Dentalium*, from the French Association for the Advancement of Science, by the construction of a reservation or marine park on the south shore of the Île Verte in front of the laboratory and of the large vivier or basin adjacent to the station and the beginning of the aquarium building with special laboratory rooms.

In the interval between 1881 and 1891 the station gradually acquired an adjacent property, the communal primary school building, the site of the battery de la Croix from the war department and several private holdings separating the laboratory from the sea, thus providing the present ample grounds and unimpeded access to a considerable extent of the water front, and making possible the union of the series of structures in one connected establishment and the erection of a substantial reservoir of 125 cu. m. capacity and a suitable pumping plant.

In 1900, upon the death of the founder of the station, his pupil and for many years his associate, Prof. Yves Delage, succeeded to his chair and his post as director of the station. In 1908–9 the laboratory

was renovated, a new modern building constructed on the site of the old aquarium and laboratory, the number of research rooms increased to thirty-eight, the circulating system extended and improved, and the vivier modified and strengthened. These very considerable improvements in the equipment of the station were made possible by private subscriptions amounting to over 60,000 francs. Of this sum Professor Chalon (Namur, Belgium) gave 30,000 francs, in addition to his replanting the garden with semitropical plants, Prince Roland Bonaparte 8,000, the Prince of Monaco 5,000, Amis de l'Université 5,500, Baron Ed. Rothschild 5,000, Baron A. Rothschild 3,000, and other friends 7,150 francs.

The system of free tables, followed during the first thirty-seven years of the life of the station, was abandoned and the plan of rental at a fixed annual charge of 1,500 francs was adopted. The budget from the State was also increased by an annual grant of 10,000 francs. It is hoped that with the income thus available a station may be maintained entirely adequate to the demands which the twentieth century imposes upon those who seek to extend the horizon of knowledge in the field of marine research.

The laboratory at Roscoff is an annex of the faculty of sciences of the university at Paris and has always been connected with the chair of zoology at the Sorbonne. Its director is appointed directly by the minister of public instruction. There is no administrative council, the director being responsible to the minister through the dean and rector of the university. The staff is appointed by the director; a resident naturalist attached to the scientific service of the marine fisheries is, however, detailed by the minister of the marine for service at Roscoff.

The station is at present in a period of transition from the system of free to that of rented tables, so that any statement of its income is necessarily incomplete and of its expenditures impossible. The station receives regularly through the University of Paris an annual grant of 6,000 francs. Beginning with 1909 an additional sum of 10,000 francs is granted annually from state funds. From the ministry of the marine a sum of 3,500 francs is received each year in return for the work done and facilities furnished by the station to the scientific service of the fisheries. The salaries (6,300 francs) of the resident naturalist, assistant préparateur, and housekeeper are paid from the budget of the State. The other members of the personnel are members of the staff of the University of Paris and receive no additional salary for their services at the station. There are twenty-four tables available for rental. Prince Roland Bonaparte, Prince Albert I of Monaco, the Swiss and Russian Governments, and the Academy of Sciences at Berlin have each subscribed for one table, and negotiations are in progress for the rental of others.

Of the funds thus received from these various sources about 4,000 francs are paid for labor continuously employed, 5,000 francs is assigned to the library and the balance for improvements and up-keep.

The station at Roscoff provides both for elementary and advanced instruction and for research. Elementary instruction is offered to university students and qualified persons in the summer from July 1 to September. It consists of daily lectures and laboratory exercises on available material. The afternoons are left free for voluntary work and excursions. Advanced instruction intended for students beginning research is also offered from August 1 to October 1. It consists principally of the technique of investigation. No fee is charged for these courses of instruction, and they are open to all properly qualified persons desiring seriously to undertake the work. The room and equipment available for this function of the station are limited, the elementary laboratory accommodating but eighteen students.

A series of conferences or public lectures are given each summer by visiting naturalists and the staff on subjects related to their research. These are open to students and to the public. The aquarium is not, however, open to the public for exhibition purposes.

The main function of the laboratory is research, and to this end it is equipped and maintained. Its laboratories are opened to all investigators on written application to Prof. Yves Delage, director, à la Sorbonne, Paris, stating the date of arrival, the period of stay, and whether or not lodgings are desired at the station. The laboratory furnishes to those whose admission is authorized a separate private laboratory equipped with microtome, paraffin oven, reagents (limited in the case of expensive reagents), glassware, etc.; supplies the animals which can not be collected by the worker himself; provides an aquarium in the large aquarium hall with running water for the exclusive use of the investigator and permits the use of the boats for collecting excursions. Persons desiring to lodge in the station are provided gratuitously with a furnished bedroom. Ten francs per month is charged for service. The number of rooms is limited and the privilege of occupying one can not be guaranteed.

The station has thirteen free tables and twenty-four for which an annual rental of 1,500 francs is charged. A copy of the "Réglement du Laboratoire" is sent on application.

The investigators at the station are free to pursue whatever researches they choose and to publish their results as they wish. They are requested to leave named material, when feasible, for the collections and to assist in the series of public lectures, but neither service is obligatory. They are expected to furnish their own microscope

and accessories. By previous arrangement collections for laboratory and museum purposes as well as for research may be made, charges being made only for the cost of fluids, containers, and packing.

The Roscoff station is open throughout the whole year. It is most frequented, however, during May–October, the abundant rains and not infrequent storms of the winter season interfering somewhat with work in the field. Several of the laboratories are provided with heating facilities for use when needed in the colder months. Roscoff is no longer wholly a provincial village, and comfortable quarters at reasonable prices may be secured at several of the numerous hotels adjacent to the station. The foreigner will find much to interest him in the quaint life of the village and of other towns in the province of Brittany, should need for diversion in the close application to research arise.

The station from its foundation has been deservedly popular. During 1908 over one hundred persons were in attendance as students or investigators. Although its clientele is largely drawn from French universities, it is frequented also by naturalists from England, Switzerland, Belgium, Holland, Russia, and Germany, and several American investigators have enjoyed its privileges for research.

The station maintains throughout the year a supply department for furnishing living and preserved animals and sea water for research and instruction. The shipments are largely made by parcels post and by courtesy are extended not only to French institutions and investigators, but also to those of other lands. From 1,000 to 1,200 parcels are sent annually. No charge is made for the animals or labor. The recipient bears merely the expense of fluids, containers, and shipping. This service makes it possible to provide classes in the higher institutions of learning in France with living material of many marine forms for class use and adds greatly to the efficiency of instruction in these subjects. A copy of the regulations regarding this service is sent on application.

The Roscoff station has no immediate relation to the fisheries beyond affording facilities to the attaché of the scientific service of the marine fisheries for carrying on his investigations. Neither does it have any programme of investigation for its staff, save only the faunistic researches of the fisheries naturalist.

The magnificent series of faunistic, systematic, morphological, and embryological monographs, which have been published in the "Archives de Zoologie expérimentale et générale," started in 1872 by the founder of the stations at Roscoff and at Banyuls, attests the extent and value of the research carried on in these two leading stations of France by the individual investigators whose work has been facilitated or made possible by these institutions.

A. STATION SEEN FROM THE BREAKWATER AT LOW TIDE. THE "PLUTEUS" IN FOREGROUND

B. STATION BUILDING SEEN FROM THE CHURCH.

BIOLOGICAL STATION AT ROSCOFF.

The Roscoff station publishes at present no series of its own, but the plan of issuing a periodical is under consideration.

Roscoff is a fishing village on the north coast of Brittany, the center of a considerable local fishery, especially of lobsters and crayfish (Palinurus), and a port to which large quantities of *Palinurus regalis* are brought from the Senegal coast for preparation for the Paris market. It is growing in importance as a residence summer resort for Parisian families, but still preserves its picturesque and unspoiled simplicity. The station is located near the head of the promontory which projects toward the Îsle de Batz. It is about ten minutes' walk from the local railway station. The buildings front upon the Place de l'Église adjacent to the picturesque old church of Notre Dame du Croix Batz and to the west open upon the Promenade du Ville along the shore. The grounds are extensive, occupying about 6,000 sq. m. of land extending along the water front for a distance of about 80 m. and projecting seaward in a large vivier. The buildings of the station represent the accretions of forty years and include not only the new modern laboratory erected in 1909, but at least five more or less ancient dwellings in the style of the "renaissance Bretagne" of the beginning of the seventeenth century, which have been converted to the uses of the institution. The buildings are separated from the strand by a narrow terrace 5 to 10 m. wide and stand 1 to 2 m. above high tide. They are arranged (Pl. XXIII, *B*, and text figure 7) upon two sides of the walled garden (Pl. XXIV, *A*), the new laboratory (10 by 55 m.) forming a wing running nearly east and west, joining at its eastern end the row of older buildings, which run at right angles to it southward for a distance of 65 m. This older wing includes five connected houses fronting upon the Place de l'Église. The new laboratory is two stories in height and the older buildings two or three. Adjacent to the corner of the two wings is a large reservoir (7 by 30 m.) with a laboratory beneath (fig. 7, *Q*), standing upon the foundations of the old battery of La Croix. The station thus possesses about 2,500 sq. m. of floor space in its various buildings.

The first building at the southern end of the eastern wing is the keeper's lodge (*L*, fig. 7) and that at the northern end is in part (*F*) the residence of the director and in part on the ground floor, machine room (*D*), and tool shop (*E*). The intervening buildings, three in number, contain on the ground floor a series of rooms, the first of which (*K*) is the general laboratory (7 by 7 m.) used for elementary instruction. This is abundantly lighted by its two glazed sides and has table accommodations for eighteen students. It is furnished with an oval central table of reenforced concrete (1.2 by 2.3 and 0.95 m. high) with concave top and raised lip and a sink (0.5 by 1.6 m.) of the same material. It is adorned with a bust of the founder of the

station, Prof. H. Lacaze-Duthiers, a replica of the bronze given to the Sorbonne by the faculty of the University of Barcelona. From this room a corridor leads along the rear of a series of seven rooms each approximately 4.5 by 5 m., serving as the laboratory (*K*) of the préparateur, physiological laboratories (*I* and *C*), storeroom for chemicals,

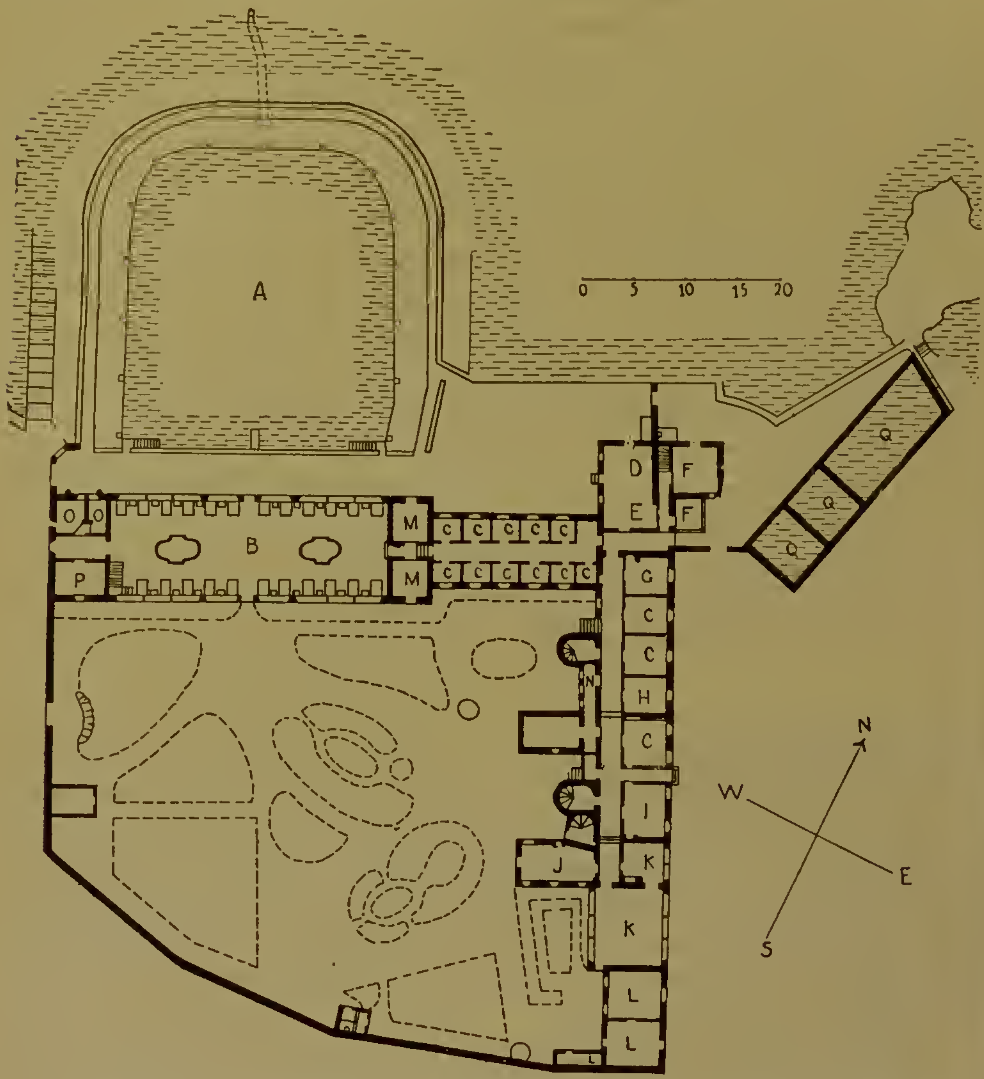
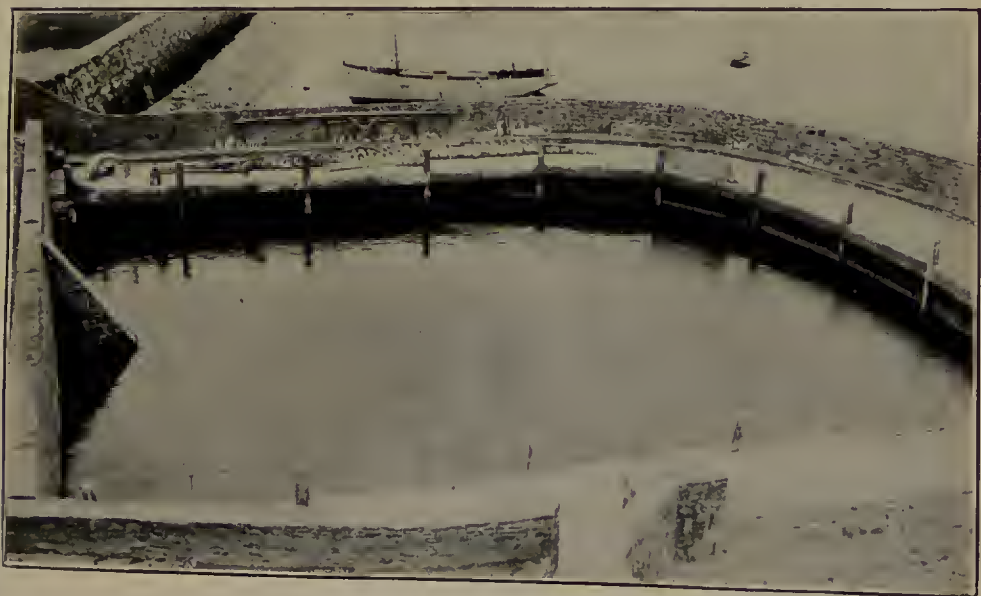


FIG. 7.—General plan of ground floor of station buildings at Roscoff: *A*, vivier; *B*, aquarium room; *C*, laboratories; *D*, engine room; *E*, machine shop; *F*, director's residence; *G*, chemical laboratory; *H*, glassware and reagents; *I*, physiological laboratory; *J*, room for zoological psychology; *K*, students' laboratories; *L*, keeper's lodge; *M*, vestibule and stair well; *N*, laboratory of préparateur; *O*, dark room; *P*, tackle and net room; *Q*, sea-water reservoir; *R*, conduit for sea water; above *K*, library and museum; above *B* and *C*, *C* of western ell, investigators' laboratories; below Q, director's aquaria.

reagents, and glassware (*H*), private laboratories (*C*, *C*), and chemical laboratory (*G*). The chemical laboratory contains a chemical hood, furnace, precision balances, chemical worktable, and a tile table and sink. It was equipped for the laboratory by the society of "Friends of the University" at Paris.

A. GARDENS OF THE STATION WITH THE NEW LABORATORY.



B. THE VIVIER.

BIOLOGICAL STATION AT ROSCOFF.

The laboratories in this part of the building are generally provided with stoves or fireplaces and are simply furnished with table, a table with lead-lined tray for dissecting and aquaria, and with suitable shelving.

In the second story of this wing, above the general laboratory, is a large (7 by 7 m.) well-lighted collection room containing glazed exhibition cases and lockers for the zoological, botanical, and geological collections illustrative of the natural history of the locality. Adjoining this is the library (3.5 by 7 m.). The remainder of this floor and the one above contain the eighteen chambers for students at the laboratory, which are simply but adequately furnished.

The two projecting towers on the garden side of this wing of the building contain the helicoidal stairways ascending to the upper stories, while in the two small wings on the ground floor are found a room (*J*) assigned to members of the "Institut général psychologique" for investigations in animal psychology and a storeroom (*N*) for alcohol and glassware.

The new wing (10 by 55 m.), entirely reconstructed in 1909 with granite facing and reenforced concrete walls, floor, and roof, is a model of simplicity and effective construction adapted to marine research. The roof, of concrete covered with bitumen and loose gravel, forms a terrace of over 500 sq. m., with commanding view over the adjacent coasts and waters dotted with islands and projecting rocks.

Upon the ground floor at the western end are the tackle room (*P*, 3.5 by 4 m.) and the two dark rooms (*O*, *O*, 2.65 by 3.7 m.), the large aquarium hall (*B*), the main entrance (*M*) from the garden and lobby, and opening on both sides from a central corridor 10 research cubicals (*C*, *C*, 2.53 by 3.85 m.), each with one window 1 m. wide. Each room is provided with a sink, table of concrete (0.5 by 3.85 m. and 0.75 m. high) with lip and fresh and salt water supply. The table slopes to a sink near one end 0.5 m. long. There are tables 0.6 m. wide, across one end and along one side of the room affording about 2.6 sq. m. of table area. There is about 15 m. linear measure of shelving in each room. Partition walls between these rooms reach the ceiling, but that along the corridor is incomplete above, affording ventilation.

The entire upper floor of the western wing is given up to research laboratories opening from a central corridor 1.5 m. wide. There are twenty-five of these rooms, the space of one being taken by the centrally located stair descending to the aquarium hall below.

These rooms are entirely separate from each other and from the corridor. They are nearly square (3.85 by 3.9 m.) and contain 15 sq. m. of floor space each, with the exception of the pair at the western end, which are slightly wider and contain 21.6 sq. m. floor space.

The ceilings are 3.3 m. high and ventilation is provided by transom windows into the corridor and a swinging sash in the window. Nearly the entire front of each room above the table is glazed, the sash (*J*) measuring 2 by 3 m. with iron frame work and panes 35 by 50 with a central pane at the level of the table 75 by 100 cm. for microscopical purposes. The floors of the rooms and of the corridors are of porphyrolithe or "wood-stone" in red tone with dark-brown border. This

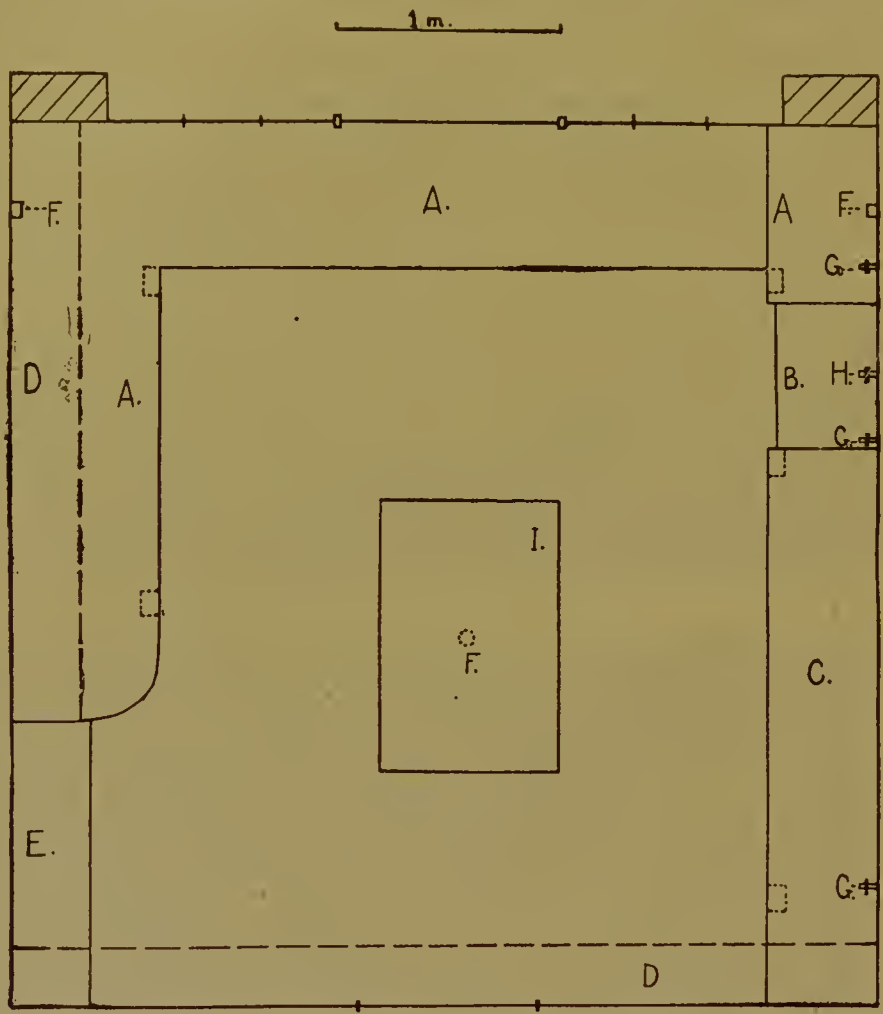


FIG. 8.—Fittings of investigators' room, Roscoff station: *A*, table with linoleum top; *B*, sink; *C*, cement aquarium tables; *D*, shelving above table or door; *E*, electric sockets (one above table *I*); *G*, salt-water taps; *H*, fresh-water tap; *I*, movable table; *J*, window with large central sash.

is a water and fire proof compound laid directly on the cement and lapped upon the base of the walls to a height of 8 cm. It makes an ideal floor for a laboratory, being easily cleaned, dustless, waterproof, slightly elastic, and not so cold as cement.

The rooms are simply furnished (fig. 8) with a sink table (*C*) of reenforced concrete (6 cm. thick) on one side (0.55 by 3.9 m. and 0.72 m. high) sloping to the sink (*B*, 0.5 m. long) near the front of the room. The table has a marginal lip and four taps for salt (*G*) and one for

(*H*) fresh water. Across the window and at one side of the room are shelf tables (*A*) of wood covered with linoleum (0.65 m. wide and a total length of 5.3 m. and 0.72 m. high) affording about 3.5 sq. m. of table space. There is also a central writing table (*I*, 0.8 by 1 m.), a cupboard (*E*, 0.35 by 1.25 m.), and 5.3 m. of shelving (*D*). The rooms are lighted by electricity, having a central droplight and desk lamp and two side sockets (*F*) at the microscopical table for electric thermostat and hot plate.

The station possesses an additional aquarium room (7 by 7 m.) and adjacent laboratory (5 by 7 m.) for experimental embryology, the private laboratory of the director, in the building beneath the large reservoirs (fig. 7, *Q*).

The pumping plant of the Roscoff station is an 8-horsepower electric motor attached to a Dumont (Paris) centrifugal pump of brass, making 1,400 revolutions per minute, with an inlet of 45 and an outlet of 65 mm. The sea pipe and mains to the reservoirs are made of cast-iron pipe (8 cm. inside diameter) of the system "joint petit" (see La Harpe, "Notes and Formules de l'Enginieur, etc.," 15th ed., 1907, p. 434), which permits the removal of any section without disturbing adjacent parts. The pipe is asphalted and has rubber packing in the joints. The sea pipe is about 20 m. in length, ending in a perforated globe in the vivier. The water is pumped to two reservoirs. One supplying the aquarium hall and the lower floor of the laboratory is placed in part on the granite foundations of a former battery adjacent to the station. This reservoir is of reenforced concrete 7 by 30 m. and 1.5 m. deep, with a capacity of 130 cu. m., with walls, floor, and roof 15 cm. thick. It is divided into three independent compartments, each with its own open ventilator (0.5 by 0.5 m.) and flushing pipes. The water is delivered from the pump into a cement channel on the roof (0.3 by 0.3 by 7.5 m.), discharging into the three compartments.

The second reservoir is placed on the roof of the lower building above the machine room. It is also of reenforced concrete and measures 5.4 by 11.8 m., with a depth of 1.2 m., walls 15 cm. thick, and a capacity of about 66 cu. m. It supplies the laboratories on the second floor and is connected with the lower reservoir. The distributing mains are of 6 cm. (outside diameter) soft-lead pipe, laterals of 4 and terminals of 2.5 cm. The cocks in the pipe are of brass. The outflow is regulated by hard-rubber cocks fastened with rubber packing in the ends of the lead pipe, provided with removable threaded tips of hard rubber, with orifices 0.5 to 2 mm. in diameter bent at an angle of 45°. The jet is discharged at a height of 10 to 20 cm. above the aquarium into a glass jar, whose overflow is practically free from the air bubbles carried down by the jet. The aquaria are drained by vertical standpipes of glass set in centrally located corks

with or without a siphon of lead or glass tubing to remove bottom water. The discharge from the aquaria is carried by rubber and glass tubing into 5 cm. cast-iron pipe along the wall, which in turn delivers the outflow to the floor tanks. The floor tanks discharge into cast-iron pipes in channels in the cement floor. The water is passed but once through the system, and, with the exception of the floor tanks, each aquarium has its independent circulation.

The aquaria at Roscoff are all intended for the purposes of scientific research and are not arranged for exhibition purposes. There are forty-four separate tanks placed in the large aquarium hall (10 by 30 m.), arranged along the sides of the building (Pl. XXV, *A*), which is brilliantly lighted by windows which completely fill the whole walls between the supporting pillars and above the level of the aquarium tables. The illumination is heightened by the white walls and ceilings. The light is thus superb for purposes of observation. To prevent the deleterious effect of excess of light upon organisms in the aquaria, wooden covers are provided and adjustable screens for the windows are arranged along the south wall. Certain aquaria are completely inclosed in opaque shelters (Pl. XXV, *B*.)

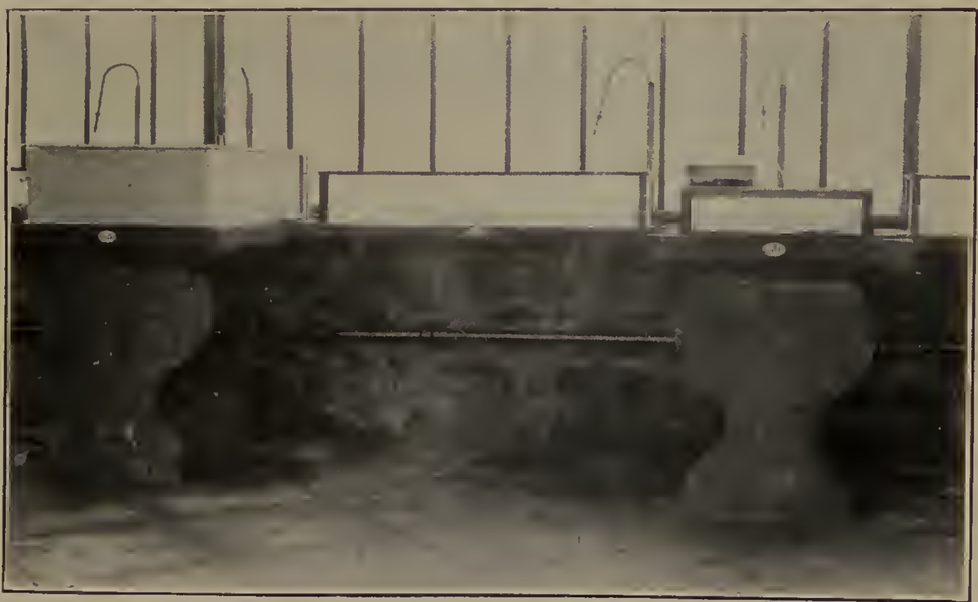
The aquaria are of various sizes and proportions. There are twenty-four on granite tables (0.8 by 1.2 m. and 0.9 m. high and 13 cm. thick) some of which have been in use for over twenty-five years without signs of deterioration. These aquaria stand with their ends toward the window (Pl. XXV, *B*). Between the granite tables there are cement shelves 0.35 by 1.35 m. and 5 cm. thick) supported by wall brackets on which stand aquaria with their long faces toward the window. The aquaria have iron uprights of angle iron (2 by 2 or 3 by 3 cm. and 4 mm. thick) set in the base. The tall aquaria (40 cm.) and the longer ones (133 cm.) have a top frame also, either of adjustable rods of iron or of small angle iron (1.5 by 1.5) fastened by screws to the uprights. The four faces are of plate glass 0.8 or 1.2 cm. thick set in common putty with the inner angles filled with litharge cement covered with glass strips, and the whole varnished with asphaltum. There is little or no leakage from the aquaria.

The dimensions used are the following (measurements in centimeters):

Dimensions of observation aquaria at Roscoff.

Height.	Width.	Length.
14	60	88
21	67	95
25	55	82
26	67	94
48	56	88
48	61	88
20	26	113
20	26	133
40	17	133

A. INTERIOR OF THE AQUARIUM ROOM, SHOWING WORK TABLES, FLOOR TANK, AND AQUARIA.



B. AQUARIA OF SEVERAL FORMS, TO THE LEFT WITH COVER.

BIOLOGICAL STATION AT ROSCOFF.

The floor of the aquarium hall contains two centrally located floor tanks, 3 by 5 m., with rounded ends (Pl. XXV, *A*), with walls of granite, 33 cm. high. The water is maintained at a depth of about 20 cm. and comes from the small aquaria. They also have an independent supply to be used when any of the small aquaria contain contaminated water or are used for experiment with poisonous materials. These tanks serve for the storage of a great variety of animals. The floor of the aquarium hall has peripheral channels 10 cm. wide and 15 deep covered with removable boards, with cross channels 20 and 30 cm. in width. These serve to carry the waste pipes which are thus easily accessible, and also to receive and carry off any accidental overflow and the water used in cleaning the floor.

In the room beneath the large reservoir is an aquarium used by Professor Delage in his famous experiments in rearing sea-urchin larvæ parthenogenetically produced by the use of CO_2. These aquaria stand on a U-shaped table of reenforced concrete 0.7 m. wide and 12 cm. thick and 0.8 to 0.95 m. high. It carries 13 aquaria (0.5 by 1 m.), joined in one circulating system, 15 cm. deep at the upper and 29 at the lower end. They are separated by cement partitions 7 cm. thick, and the side of each is formed by two panes 47 cm. long and 15 to 30 cm. high, according to its location, cement posts 7 by 7 cm. standing midway on each side. The windows of the room have adjustable wooden shutters to reduce the light.

The station at Roscoff has a superb equipment for the collection and study of living animals under the natural conditions of their usual environment. It consists on the one hand of a large vivier or shore aquarium, accessible under all conditions of weather and tide, absolutely protected from destruction, and provided with adequate means of change of water under satisfactory conditions. This artificial preserve is supplemented on the other hand by a natural park on the adjacent shore, under the control of the station, where the fauna may be allowed to develop undisturbed except as needed by the station.

The vivier of the station (Pl. XXIV, *B*) is specially arranged for biological purposes. It serves as a reservoir from which the water for the station is pumped and as a storage basin for large animals and for animals under culture or observation. It is a square basin (about 36 by 36 m.) with rounded outer corners jutting from the shore seaward, containing nearly 1,000 sq. m. of surface. A heavy wall of masonry 4 m. thick at the base forms its outer boundary. On the inner side of this wall is a reenforced concrete platform 4 m. wide supported by pillars of the same material. The faces between the pillars are closed above the water level by doors of tarred planking, thus forming a dark gallery, 70 m. long and 4 m. wide, where shelter-loving, fixed animals readily develop under quite natural conditions.

The bottom of the vivier is made of concrete and slopes from the margins (3.5 m.) to the gate (4 m.), facilitating the cleaning when necessary and insuring the retention of the water at times of low tide.

From the vivier a cement conduit (fig. 7, *R*) 0.8 m. in diameter, extends seaward for about 100 m. to a point near low-tide level. By means of this the vivier can be filled at high tide with pure sea water from the channel relatively free from shore contamination. The conduit is closed with an iron gate regulated from the platform by a screw.

The marine park is situated between the Îsle Verte in front of the laboratory and the vivier, at some distance from the island on a rocky strand exposed at low tide. It is set aside under the exclusive control of the station as a collecting ground where continuous observations may be made on animals in a natural habitat or where cultures may be conducted. It is a rectangular area 25 by 50 m. inclosed in a wall of loose granite rocks and containing many rocky shelters for the protection of the fauna.

The marine equipment of the Roscoff station includes a wooden cutter of 18 tons, the *Pluteus* (Pl. XXIV, *B*), with a 3-cylinder 30 horsepower "Wolverine" motor for auxiliary power. The boat is 13.6 m. long, 3.35 m. wide, has a draft of 1.7 m., and carries two masts with full rigging for sails. There is a cabin 4.5 m. long forward with worktable and bottle racks and a galvanized-iron live box amidships with free circulation to the outside. Circulation is assured by having the water for the motor-jacket drawn from this well. The dredging winch is on the starboard side geared to the motor forward of the cylinders, and a friction belt connects the gearing with the cable drum on the port side of the engine room. The cable is passed through the deck forward between rollers on the prow. The vessel is driven backward while dredging. The *Pluteus* carries 320 m. of 15 mm. galvanized-steel cable, and shorter lengths of smaller sizes.

The station also has two sailboats, the yawl *Laura* of 2 tons, 6.5 m. long, and the *Bayard* of 0.75 ton, 3.5 m. long, and three rowboats.

The field equipment includes a 10 m. and a 4 m. beam trawl, a coral tangle, an assortment of nets, seines, and dredges, a large plankton net on the Hensen model, and small plankton nets for use at full speed. For oceanographic work there is a Mill water bottle, a Leger bottom sampler, and a reversing thermometer. For continuous record of temperatures in the channel about 850 m. from the laboratory there is installed a Fournion self-registering thermometer. A receptacle of liquid carbon dioxide at the field location is connected by a small copper tube with the registering apparatus in the laboratory. With this apparatus it is possible to obtain a continuous record of the temperature and to see at a glance in the laboratory at any time the temperature of the sea water at the field location. A Fournion self-register-

ing tidal gauge with a continuous record accessible at all times in the laboratory is also installed at the station.

The laboratory possesses an ample equipment of glassware and chemicals and a number of pieces of physiological apparatus, the gift of Professor Richet, including a Verdin registering apparatus and signal, a Marey myograph, and a Du Bois-Reymond electro-physiological apparatus. Other instruments are supplied from the laboratories of the Sorbonne in Paris as needed, not only for physiological work but also for morphological investigations, the damp winter climate at Roscoff making it difficult to keep fine instruments at Roscoff continuously. The station keeps at Roscoff, however, an equipment of microscopes, of dissecting lenses of Lacaze-Duthier's model and several microtomes and brings for summer season, June–October, a generous equipment from Paris. One of the older laboratories is amply equipped for chemical work and one of the new ones is to be equipped by the Prince of Monaco for oceanographic investigation. A Fabre-Domergue rotator apparatus with hot-air motor for rearing larvæ is also provided.

The buildings are lighted by electricity and the new laboratories are supplied with fresh and salt water and it is expected that gas will shortly be available in Roscoff.

The library of the station is as yet undeveloped. It contains about 2,000 numbers, coming in part from the library of Professor Lacaze-Duthier, mostly monographs, special works, and reprints, but it is to be largely increased in the near future. The museum is intended to illustrate only the local fauna and flora. It includes a well labeled and mounted and well displayed collection of the marine life of the vicinity, quite complete and carefully identified, often by specialists, the sponges by Topsent, isopods and amphipods by Chevreux, echinoderms by Mortensen and Hérouard, nemerteans by Oxner, planarians by Francotte, annelids by Pruvot, Fage, and Joyeux-Laffuie, bryozoans by Jolliet, parasitic copepods by Quidor, decapods by Delage, gastropods by Vasseur, Robert, and Hecht, *Amphineura* by Vlès, lamellibranchs by Vasseur, cephalopods by Vasseur and Camus, ascidians by Pizon, and the fishes by Marty, Guitel, and Moreau. The collection of seaweeds is from the herbarium of Professors Chalon and Siderot and contains about 500 sheets and a number of microscopical preparations. A card catalogue is kept of the collections, with notes on localities and authority for the determination.

The museum also contains an interesting collection of abnormalities, of sexual products and larval forms, and of materials representing experimental work carried on at the station.

The environmental conditions at Roscoff are such as to make easily available for research an abundant and varied fauna. The shores of

granite and schist afford a firm substratum for great beds of *Fucus* and *Laminaria*, and great stretches of shingly beaches provide *Ulva* and *Enteromorpha* zones, while in the deeper waters *Zostera* abounds. The extreme diversification of the coast line, with the numerous bays and promontories and many islands and jutting rocks, afford a shore of great extent and variety within a relatively short distance of the station. All conditions of rock, shingle, sand, and mud, each with its characteristic fauna and flora, are to be found close at hand.

Added to this variety of shore is the fact of a wide tidal amplitude reaching 8 and exceptionally 9 or 10 m. at spring and exposing to the shore collector, without the aid of boat or dredge, vast expanses of rock and weeds with tide pools, mud and sand flats of infinite variety. The collecting grounds are, moreover, immediately accessible from the doors of the laboratory and the naturalist enjoys direct and easy access to his material and exceptional opportunities to observe its natural habitat. Owing to their extent there is, moreover, little danger of the exhaustion of the collecting grounds.

The adjacent region for a distance of 5 to 10 km. from shore is within the 50 m. line. A limited region of 110 m. depth is found at a distance of 16 km., while the 100 m. line in general is 45 to 50 km. to the northwest. The bottom and pelagic fauna of deep water is therefore not generally available at Roscoff and the plankton as a rule receives large neritic contributions. The fauna in general is quite similar to that of Plymouth. (See p. 163.) A full account of the local conditions and the distribution of the local fauna will be found in the paper of Pruvot (1897).

Temperatures range from 4° to 5° C. in winter to 18° to 20° C. in summer. The winter climate at Roscoff is mild, figs, camellias, palms, and pelargoniums living in the open air, and freezing weather and snow being unusual.

The considerable movement of tidal water and the absence of large streams in the neighborhood insure nearly the normal salinity to the water at Roscoff, while the distance from large cities and the location of the laboratory upon a promontory projecting some 5 kilometers from the coast line remove the possibility of any considerable contamination. The water for the station is taken at highest tide once in two weeks through the cement pipes extending seaward 100 m. from the vivier. The impounding permits all suspended matter to sediment and the smooth cement floor is cleaned each time before admitting the fresh supply. The purity of the water supply at Roscoff is thus noteworthy.

The station at Roscoff affords unusual attractions to naturalists wishing work upon the littoral and neritic fauna, to study living animals in their native habitat, to secure large quantities of material, or to carry on developmental or experimental studies where aquaria

with pure water supply are essential. A cordial welcome is extended to all foreign guests.

Literature: Lacaze-Duthiers (1874, 1877, 1881, 1891, 1898), Dean (1894), Sand (1897), Pruvot (1897), Francotte (1907), Menegaux (1905), Delage (1908, 1909).

MARINE LABORATORY OF THE NATIONAL MUSEUM OF NATURAL HISTORY AT TATIHOU NEAR SAINT-VAAST-LA-HOUGUE (MANCHE).

Director, Prof. Ed. Perrier, director of the Museum of Natural History and professor of comparative anatomy, Museum d'Histoire Naturelle, 57 Rue Cuvier, Paris.

Assistant director, Dr. R. Anthony, 55, Rue de Buffon, Paris. January, April, and July–August at Saint-Vaast-la-Hougue.

Superintendent, M. A. E. Malard, Saint-Vaast-la-Hougue.

Captain and machinist, M. Ch. Liot, Tatihou.

In addition, one sailor and one servant.

Telegraph address: Laboratoire, Saint-Vaast-la-Hougue.

The granitic coast of Saint-Vaast and its vicinity with its rich fauna has long attracted naturalists to its study. From the time (1831) when Audouin and H. Milne-Edwards frequented these shores in the summer months, and opened temporary laboratories in hotels or fishermen's cottages, to the present, a long line of illustrious investigators, A. Milne-Edwards, Nordmann, Keferstein, Claparède, Grube, Brandt, Quatrefrages and many others from France and foreign lands, have sought these shores for the study of marine life.

A permanent station here was not established until 1881, when upon the petition of the professors at the National Museum of Natural History the station at Saint-Vaast was created by the minister of public instruction, and Prof. Ed. Perrier, a leader in the enterprise, was made its director. Under his charge its resources have been developed and it has been brought to a high state of efficiency. In this undertaking he has had the able services of M. Malard, for many years resident naturalist of Saint-Vaast and since 1906 the efficient aid of Doctor Anthony, the director-adjoint, who has given much attention to improving the marine equipment and developing its piscicultural features.

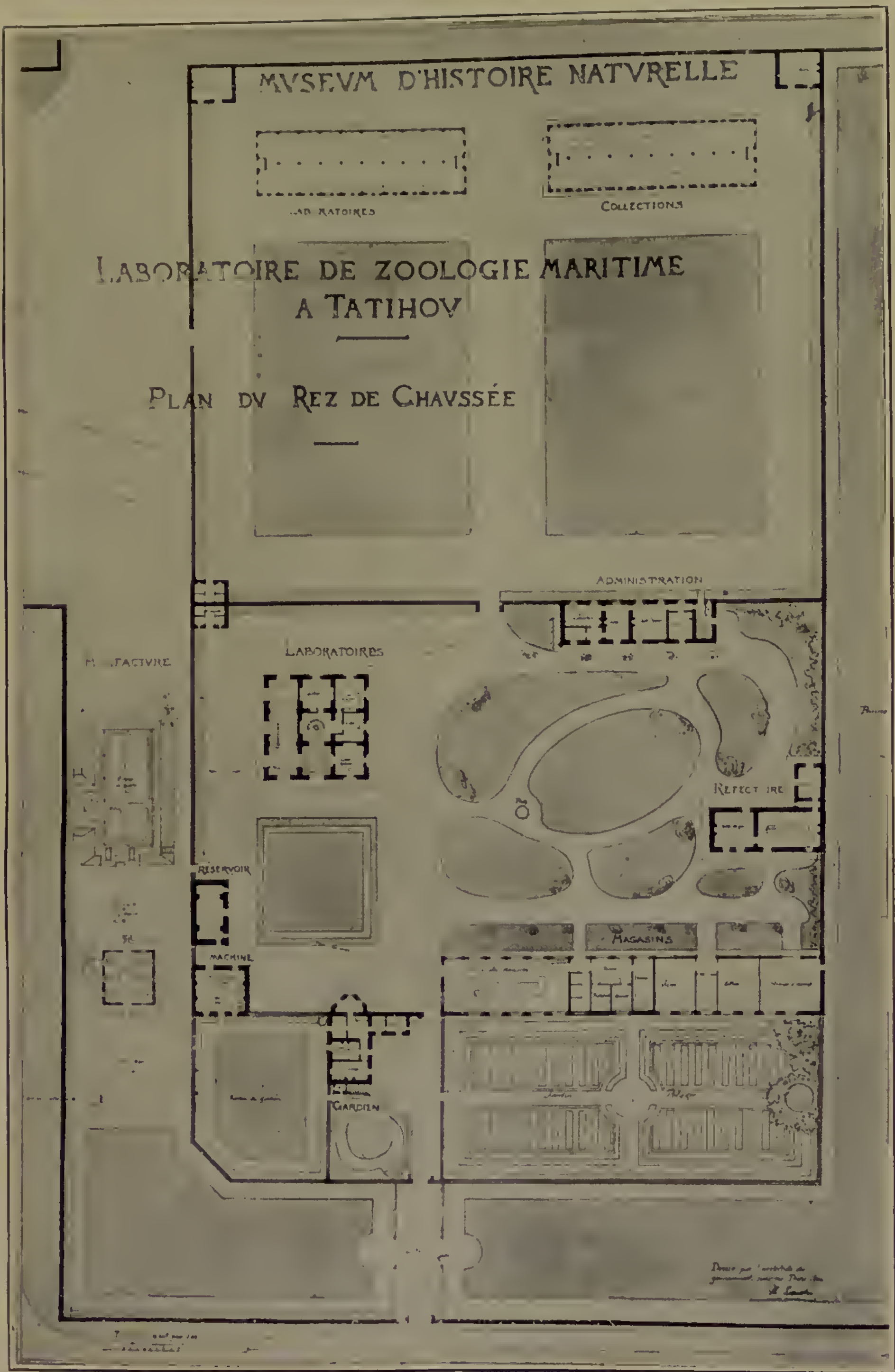
The director is appointed by the minister of public instruction and the other members of the staff by him also, upon the nomination of the director. The director-adjoint has immediate charge of the station and is in residence at Saint-Vaast for four months of the year. The superintendent (chef-de-travaux) is in continuous residence and has immediate charge of the laboratories, aquaria, and collections. The station is fortunate in its patron-mechanician, M. Ch. Liot, to whose knowledge of local conditions and courteous attention visiting biologists owe much. The assistant director makes annual administrative report of the scientific operations of the station which is published in the "Annales des Sciences Naturelles (Zoologie)".

The station is attached directly and solely to the National Museum of Natural History at Paris, of whose staff its directors are members. Its annual budget is included in that of the National Museum of Natural History from the ministry of public instruction, and consists in addition to the salaries of the director and assistant director, whose services are given mainly to the museum, of about 3,500 francs per annum for salaries of resident staff and subalterns, 4,170 francs for upkeep and equipment, a variable sum (3,000 francs in 1908) from the ministry of the marine, and an annual allotment (2,000 francs in 1908) from the ministry of fine arts for maintenance and repairs of the building, a total (in 1908) of 12,770 francs. Of the unassigned sum (7,170 francs) 5,170 francs are spent in maintenance of the boats, aquarium, grounds, laboratories, and collections, 1,000 francs for instrumental and chemical supplies, and 600 francs for the library.

Research is and has been the main object of the Saint-Vaast station. Since the museum conducts no examinations for degrees, the laboratories are not much frequented by students, but principally by investigators including many foreigners from Russia, Scandinavia, Germany, Switzerland, England, and Spain. Competent students and investigators are admitted on application to the director without charge. Investigators are supplied with private laboratory, chemicals, reagents, and glassware and material for research or the means of collection. Furnished quarters are provided gratis with a nominal charge of 5 francs per month for service, and board at the common mess hall for 3 francs per day. Large amounts of reagents and glassware are charged at cost. The station has four microscopes, which may be furnished to investigators on application in advance to the director. Collecting, except for commercial purposes, is free. Everyone is free to work as he chooses and publish his results where he will, but the director offers the "Annales des Sciences Naturelles," of which he is editor, for suitable papers, and résumé of all published work is to be furnished for inclusion in the annual report. No printed rules are issued.

The station conducts a biological supply department, furnishing living animals and plants at cost of containers and shipping, and prepared material at cost of preparation. It is especially well situated for furnishing marine algæ and sends large amounts to educational institutions and investigators.

In addition to the individual researches of its staff the station conducts several lines of investigations; the first, because of its relation to the department of the marine, is a systematic attack upon the problem of hatching fish eggs and rearing the larvæ, especially those of the turbot, through the critical stage. For this purpose hatching devices of various types, storage tanks, and improved



PLAN OF BUILDINGS AND GROUNDS AT ST. VAAST-LA-HOUGUE.

By courtesy of Doctor Anthony.

breeding aquaria have been installed and various feeding methods tested with a view to bringing turbot hatching to a practical basis.

A second line of investigation followed systematically is that of anatomical researches upon the *Cetacea* and *Pinnipedia*. The extensive tidal flats and the extreme amplitude of the tides results in the frequent stranding of these marine mammals on the coast near the laboratory. The laboratory is accordingly equipped with photographic apparatus and special dissecting appliances for conducting these researches as opportunity offers. The work of the station in this field is supplemented by that of the museum at Paris, where anatomical models are made from the dissections for exhibition.

A third line of investigation is that of systematic plankton research carried on at regular intervals at the same locality near the station. The publications of specialists on these collections will be reissued in a special volume on the "Études sur le Plankton de la Baie de la Hougue." The station issues no other publications.

Saint-Vaast-de-la-Hougue is a fishing village on the eastern shore of the Manche Peninsula, about eight hours from Paris, reached by local train from Valognes, on the line to Cherbourg, or by steamer from Le Havre. The station is located on the Île Tatihou, opposite the village of Saint-Vaast-la-Hougue, in extensive grounds and numerous buildings originally used for hospital purposes. The island is a mile from the village, being separated from the mainland by the passage known as the "Rhun," and is accessible at low tide on foot or by carriage from the mainland, but the station maintains a ferry service for visitors, by previous arrangement, from the village quay, when tide permits, to the island with its motor boat, the *Tictac*.

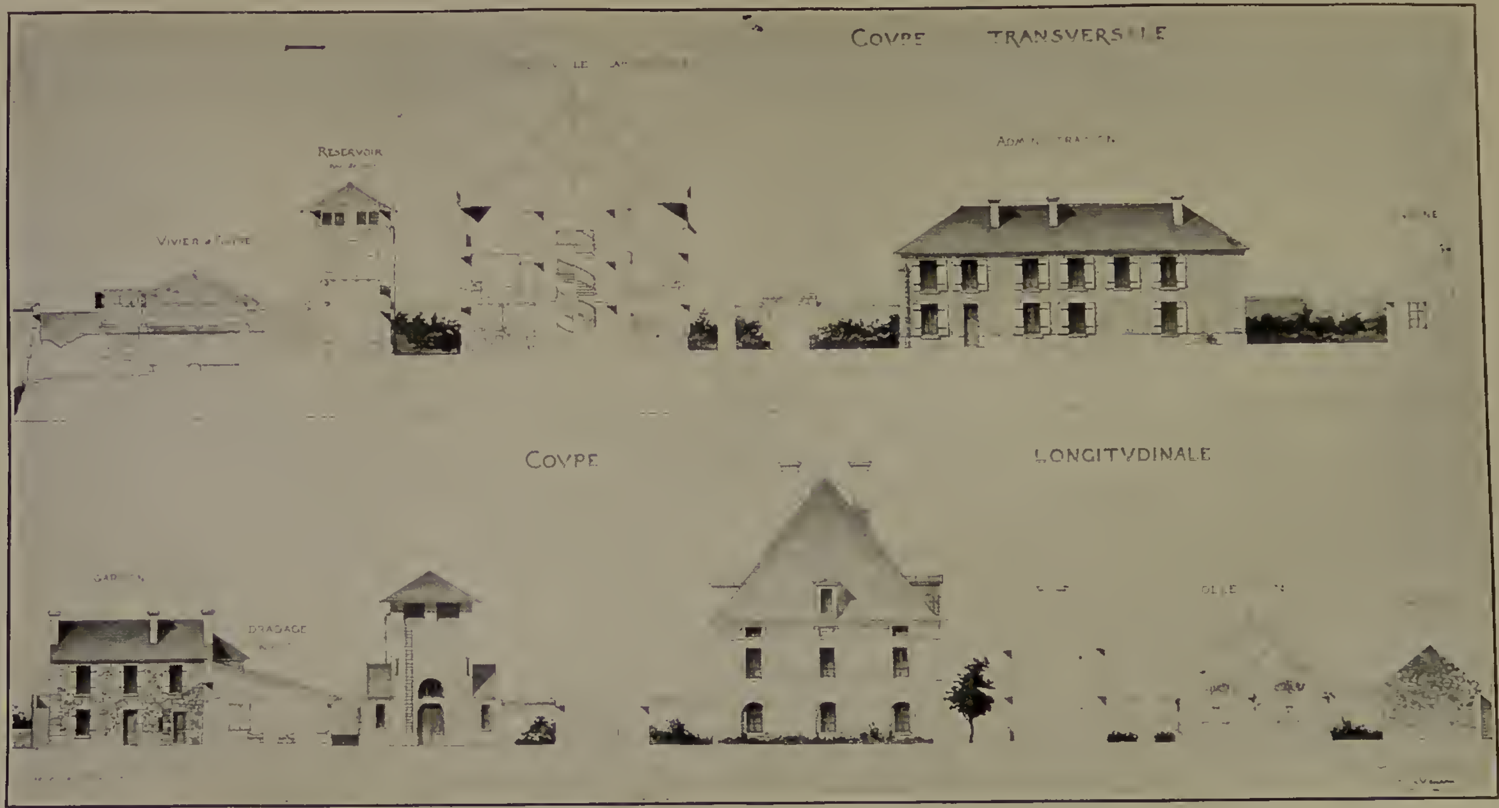
The island contains about 27 hectares, of which a small part is included in the walled inclosure (200 m. square) of the station, which occupies its western part and controls a small part of the western coast with a small shelter harbor. The buildings are distributed upon a level prairie, at an elevation of 7 m. above high tide, and in comparison with most stations erected in narrow quarters at the seashore the station at Saint-Vaast is one of magnificent distances.

The establishment includes in all fourteen buildings, all but two of which, the hatchery and fish basins, are inclosed within the inner wall (Pls. XXVI and XXVII) in an area 83 by 57 m. The buildings for the most part belonged to the former hospital erected for French soldiers returning from Maximilian's Mexican campaign, but never used. They have been modified to meet the needs of a biological station and supplemented by new constructions for water supply and fish culture. The buildings include a long storehouse (8.5

by 46 m.), in which have been established a large, well-lighted "Salle des dragages," or sorting room (7.7 by 15 m.), with adjacent storeroom (3 by 7.7 m.), chemical laboratory (4.85 by 6 m.), glass-ware room (3 by 7.7 m.), dark room (2.75 by 3 m.), the remainder of the building being still used as warehouse for storage.

The main laboratory building (14 by 14 m.), with two stories and a mansard floor, contains on the ground floor the aquarium room (4 by 13 m.) and four laboratories, two of which (4.2 by 4.7 and 4.15 by 4.15 m.) are devoted to experimental fish culture—one provided with a Fabre-Domerge rotator and the other with a new apparatus devised by Doctor Anthony for hatching turbot eggs. There is also upon this floor the laboratory (4.15 by 9.2 m.) for micro-photography and one laboratory not specially appropriated (3.05 by 4.2 m.). A centrally located helicoidal granite stairway of remarkable construction leads to the upper stories—the second containing eight rooms, four (each 4.2 by 4.2 m.) of which are equipped for two persons, and three for one (each 3.05 by 4.2 m.), while the remaining room serves as an office of the assistant director. These rooms are intended to serve both as laboratories and bedrooms, and are provided with simple but sufficient furniture—a laboratory table, a sink with fresh water, a chemical table with lava top, and an aquarium sink table (1.1 by 1.1 m. or 0.8 by 0.8 m., with the corner cut back), with lead-lined tray 5 cm. deep, and salt-water supply. The four rooms upon the ground floor have a similar laboratory equipment. On the third floor are eight rooms of corresponding dimensions furnished as bedrooms only. The central hall on this floor contains the large iron fresh-water tanks supplying the laboratories.

In the same inclosure with the laboratory building is the engine house (6.3 by 8.3 m.), the water tower of granite masonry, with storeroom below (5 by 8 m.), and at the end of the lawn the lounging room, dining room, and kitchen, rendered necessary by the isolation of the station upon an otherwise unoccupied island. Close at hand is a stone structure of two stories, containing the residence and laboratory of the director. In the paddock to the north, at some distance from the other buildings, are two long one-story wooden buildings, each 8.5 by 24 m., originally intended as contagion wards for cholera patients returning from Mexico. The one to the east serves as a museum and is fitted with museum cases formerly at the Jardin des Plantes in Paris. The building to the west contains the library (8.5 by 9.25 m.) and a large room used for storage of nets, seines, and fishing gear, and is not as yet divided into laboratories, as shown on the plan (Pl. XXVI). Outside of the inner wall but within the outer inclosure is the underground reservoir and the fish-culture plant, consisting of two one-story



TRANSVERSE AND LONGITUDINAL SECTIONS THROUGH BUILDINGS AT ST. VAAST-LA-HOUGUE.

By courtesy of Doctor Anthony.

wooden buildings, with thatch roof, a hatchery (7.5 by 7.5 m.), with Dannevig hatching apparatus and simple laboratory furniture, making it possible to use the room as an overflow laboratory, and a covered tank house (6.5 by 19 m.) containing three large tanks with masonry walls nearly a meter in thickness and a total capacity of about 300 cu. m. Turbot used in hatching experiments are stored in these tanks. The residence of M. Ch. Liot, the captain and machinist, and two houses for servants are also found upon the grounds.

The receiving rooms and the laboratory rooms are provided with stoves, grates, or oil heaters, and salt and fresh water are piped to all the laboratories, but there is no gas or electricity to be had on the island.

The equipment of the laboratory with glassware and chemicals for morphological work is quite ample. The station possesses five student microscopes of good grade, a Zeiss-Greenough binocular, a rocking and a Minot rotary microtome, paraffin oven, autoclave, Cogit bacteriological thermostat, centrifuge, precision balances, mercury pump, etc. There is also an excellent equipment for photographic work, including a camera for field work, a Zeiss apparatus, a stereoscope camera for microscopical work, and a suitable dark room.

The library of the station contains about 2,500 volumes, including complete or partial sets of many French serials and reports of expeditions, the Zoological Record, many monographs and papers. It is in regular receipt currently of a dozen periodicals. The library is catalogued and systematically arranged.

The collections are quite extensive, are well mounted and displayed, and fully labeled. They represent the local littoral and bottom fauna. The annelids, mollusks, hydroids, fishes, and water birds are well represented.

The herbarium contains about 800 sheets, largely representing the local marine algæ named by such eminent authorities as Shuret, Bornet, and Sauvageau.

The equipment for hydrographic work includes an assortment of areometers of Poulenc, Paquet, and of Thurneyssen, Richard reversing water bottle with Thurneyssen thermometer, an electric light and accumulator (Apparat Trouvé) for determining the transparency of the water, and a Thoulet bottom sampler.

The character of the marine equipment of the station is determined largely by the fact that the shoal waters of the neighborhood necessitate the use of boats of light draft and do not call for extensive apparatus for their exploration. In 1907 and 1909 the laboratory secured two new boats, the *Tictac*, a motor boat 10.8 m. in length,

2.8 m. in width, and 1 m. draft, and an 18-horsepower Forest & Gallis gasoline automobile engine, giving a speed of 8 knots. The boat has two masts and lateen sails, has a closed cabin forward of the engine, and cockpit which may be closed with canvas. She carries a crew of 2 and 20 passengers. A hand winch is provided for dredging or trawling. A second motor boat, the *Comatula*, (7 m. long, 2.1 m. wide, 0.65 m. draft) with an 8-horsepower motor, is used for lighter work. The station has a good assortment of shore collecting implements, dredges, trawls, fish traps, seines, and plankton nets of muslin and of silk.

The aquaria for storage and observation of living material are located in the aquarium room (4 by 13 m.) on the ground floor of the laboratory building. There are twelve tanks arranged against the outer walls of the room, unevenly and sometimes inadequately lighted by windows of customary location. The walls (25 cm.) and base (20 cm.) resting on brick piers are of granite, 0.8 m. high and 0.75 m. wide, and lengths of 1.2 to 1.4, 2, and 3 m., and the two corner basins with narrow (0.35 m.) oblique fronts. The panes set in the granite walls range in size from 0.8 by 0.35 m. to 0.8 by 1.8 m. and are 30 mm. thick.

Against the inner wall is a row of thirteen cement basins (50 by 50 cm. and 26 cm. deep) with cement partitions 8 cm. thick and plate-glass fronts 26 by 50 cm. and 1 cm. thick. These are used for smaller invertebrates and afford a variety of conditions of rock, sand, mud, *Zostera*, *Lithothamnion*, etc., and one is provided with an automatic tidal siphon. Through the center of the room is an aquarium table of granite 72 cm. high, 70 cm. wide, and 7 m. long, with overhead water supply 82 cm. above the table. The top of the table slopes to the center for drainage. In the sorting room (Salle des dragages) there are two handsomely finished aquaria for observational and photographic work, (Pl. XXVIII, *A*) made after the Roscoff pattern. They are mounted on slabs (10 cm. thick) of black and of white marble to afford suitable backgrounds for photographic work, and the table is about 20 cm. wide outside of the aquarium for notebooks or apparatus. The aquaria are 86 cm. long, 45 cm. wide, and 17 cm. deep, with plate-glass sides 6 mm. in thickness, held in place by corner posts of angle brass (2 by 2 cm. and 3 mm. thick), with a top band 2 cm. wide of T-shaped brass fastened to the top of the corner posts by L-shaped pieces of brass. The free angle of the T-band receives a carefully fitted plate-glass cover. A wooden cover is provided for keeping the aquaria in the dark when desired. These aquaria have tin-lined brass pipes in goose-neck form for overhead water supply and vertical standpipes with surface outflow.

A unique and satisfactory part of the equipment of the sorting room is a large U-shaped sorting table 1.06 m. wide, 0.8 m. high, a total width of 3 m., and a length of 6 m. (Pl. XXVIII, *B*). The top

A. OBSERVATION AQUARIA.

B. SORTING AQUARIUM TABLE.

After photographs by Doctor Anthony.

AQUARIUM ROOM AT ST. VAAST STATION.

is dished, forming a channel 16 cm. deep, and is lined with cement. This table serves for the leisurely sorting and washing of the contents of the dredge or trawl, as a large shallow aquarium or as a dissecting table for large animals.

The pumping plant housed in the machine room consists of a 3-horsepower Gnome petrol motor with a 5-horsepower Bénier hot-air motor in reserve. There are two double centrifugal pumps of Dumont type of bronze located 6 m. above level of the low-level reservoir and 8 m. below the high-level one. There is also a Baume-Vidal windmill, with a 5.8 m. wheel and a maximum force of 4 horsepower, specially geared, a 3-cylinder plunger pump of bronze. The windmill has proved to be very efficient in operation and often meets the pumping demands of the laboratory.

The water is drawn from a subterranean cement reservoir 2 m. below the surface (8 by 14 m. and 3 m. deep, with a capacity of 270 cu. m.), filled by a 20 cm. reenforced concrete conduit running 100 m. to a point on the beach. An automatic valve at the reservoir admits the water when the tide is 2 m. short of high tide and prevents its escape as the water falls. The level of the gate is such that at least 2 m. of water will always be retained by the reservoir. From the pump the water passes to the fish basins or to the high-level reservoir in the granite water tower, with a capacity of 30 cu. m., and is distributed thence in the open circulating system which supplies the aquaria, laboratories, sorting room, and, if need be, the hatchery and fish basins also. The mains (9 and 6.2 cm.) and laterals (3 cm., outside diameter) are of soft lead, with brass cocks and valves. The aquaria have overhead supply, delivering to the bottom of the aquaria through glass tubes with air inlet at the top. The outlets discharge surface water from the aquaria into floor channels beneath the tanks.

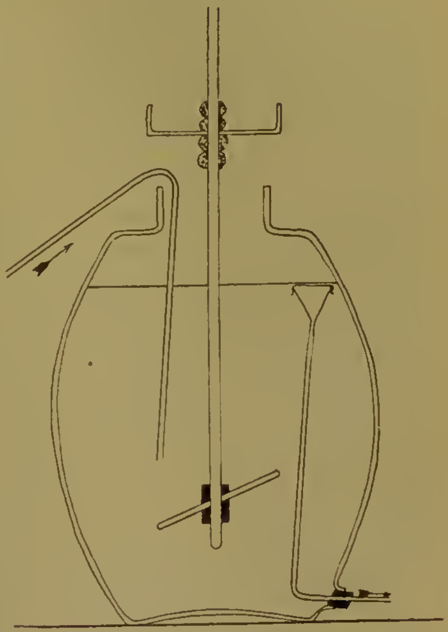


Fig. 9.—Anthony's turbot rearing tank, for the experimental hatching of the turbot.

The experimental hatchery equipment includes Dannevig boxes (now discarded), and the apparatus of MacDonald, Chester, and Garstang, a Fabre-Domergue rotator with a one-fourth-horsepower Heinrici hot-air motor and a new apparatus on the principle of the Fabre-Domergue rotator (fig. 9), devised by Doctor Anthony (fig. 9). It consists of a barrel or drum of reenforced concrete (92 by 102 cm.) on a

stout stand with a dozen small plate-glass windows inserted at a convenient height for observation of the contents. Inside the drum is a rotator with disc 30 cm. in diameter driven by hot-air motor. Circulation is provided by a supply pipe discharging above the disc and a surface outflow pipe with funnel covered with gauze.

As annexes to the field resources the station controls a large oyster park between Tatihou and St. Vaast and the Ile de Terre, one of the Iles de St. Marcouf (area, 0.5 hectare), 7 miles southeast of the station. The shores of this rocky island form an admirable biological reservation for the growth and observation of the shore fauna under natural conditions.

The environmental conditions at St. Vaast present a rocky shore where granite rock strewn with bowlders affords attachment and shelter for an abundant flora and fauna. In the "Rhun" between the Ile de Tatihou and the mainland the loose rock is built into the walls of the numerous oyster parks. Elsewhere there is a great variety in shore conditions, rocks of granite, and schist, shingle, gravel, sand, and mud, with beds of *Zostera*, *Fucus*, *Laminaria*, and red seaweeds. The tides, which attain an extreme amplitude at spring of 11.4 m., expose a littoral zone often exceeding a kilometer in width of these varied environmental conditions. The fauna and flora are much like those of the littoral areas at Plymouth and Roscoff, with an abundance of attached and burrowing forms. The adjacent waters are shallow, a large territory being less than 10 m. in depth at low tide. Depths of 25 and 52 m. are to be found at distances of 2.5 and 10 miles, respectively. The bottom is sandy or of fine sand and mud with occasional banks of broken shells and rock.

The fauna and flora are predominantly neritic, and in their main features are like those at Roscoff and Plymouth, but with greater proportion of neritic elements.

The plankton is characterized by the large admixture of neritic species and larval stages. Résumés of the local fauna and flora with full bibliographies will be found in the papers of Fauvel (1905) and Corbiére (1905), prepared for the meeting of the French Association for the Advancement of Science at Cherbourg, in a volume entitled "Cherbourg et le Cotentin."

Literature: Perrier (1888), Malard (1895, 1905), Sand (1897), Anthony (1907, 1908), Lefranc (1908).

MARINE ZOOLOGICAL LABORATORY OF THE UNIVERSITY OF CAEN, AT LUC-SUR-MER (CALVADOS).

Director, Prof. Jean Joyeux, Laffuie, 70 Rue d'Assas, Paris.

Acting director, Prof. Emile Topsent, professeur du zoologie, Laboratoire Zoologique, Université de Caen.

Assistant, Dr. Charles Lebailly, Laboratoire Zoologique, Université Caen.

In addition a keeper and captain, a sailor-collector, and a laboratory servant.

Telegraph address: Laboratoire, Luc-sur-Mer (Calvados), France.

The station at Luc-sur-Mer is an annex to the University of Caen and is associated solely with the chair of zoology in that institution. The members of the staff of the department of zoology are also members of the staff of the station, receiving their appointment from the minister of public instruction. The station has no board of control, the director being responsible directly to the dean of the university.

The budget of the station is included in that of the zoological laboratory at Caen, and its entire staff, including the servants, receive their salary directly from the university budget and serve at the station without extra salary during the summer. The keeper alone is a permanent resident at Luc-sur-Mer. The station receives an annual grant of 2,500 francs for its upkeep. The salaries for service, amounting to about 1,700 francs annually, the upkeep of the library, and much of the equipment come directly from the university budget. The entire budget often supplemented by laboratory funds is used in the upkeep and improvement of the building and equipment at Luc-sur-Mer.

The station is used during the university year as headquarters for zoological excursions of classes from the university and is formally opened for instruction and research from July 1 to October 1 and may be temporarily opened at the Easter recess. Laboratory instruction is conducted by Doctor Lebailly during the summer season for qualified elementary students. The course consists of the informal study of marine types and of field excursions. An advanced course in histological technique for students beginning research is given three times a week in August by Professor Brazil of the University of Caen. The laboratory is also open to competent investigators. No fees are charged for the use of the laboratory; material for study and research, dissecting instruments, microscope, microtomes, paraffin ovens, reagents, chemicals, apparatus, and literature needed are supplied either from the laboratory or from the university at Caen. The use of the boats and collecting apparatus and of special aquaria can also be granted as a rule upon application. Collection of material for study, research, or museums is permitted, but the collector must provide his own containers and fluids.

Persons desiring admission should apply in advance to the acting director at Caen, stating the time for which the table is desired and whether or not lodgings at the station are wanted. Simply furnished chambers accommodating eight persons in all are provided in the station building, and their use is granted gratuitously to students and others, as far as feasible on application. A fee of 5 francs per month (or less) is paid for service.

Luc-sur-Mer is a popular summer bathing resort with numerous restaurants and small hotels in close proximity to the station, where suitable accommodations can usually be obtained.

The station conducts no biological supply department, bears no relation to the fisheries, has no formal programme of research, and issues no series of publications. The researches of its staff, published in the leading biological journals in France and elsewhere, deal mainly with sponges, parasitic protozoa, and cestodes.

Luc-sur-Mer is a seaside village on the south shore of the Baie de Seine, west of the mouth of the Orne, nearly midway between Le Havre and Cherbourg, reached in forty to sixty minutes from Caen (Gare de Saint-Martin) or in six to ten hours from Paris via the line to Cherbourg. The station is located near the eastern end of the marine promenade about five minutes walk from the railway station. It consists of a row of buildings fronting immediately upon the street along the beach, located in grounds containing about 750 sq. m. and separated by a street from the garden and residence of the director, belonging to the station.

The buildings are 20 m. from the sea wall and 3.5 m. above high tide. Fronting to the north upon the street along the beach are four connecting stone buildings, the aquarium building (7 by 16.5 m.) two stories in height containing the aquarium room on the ground floor and the director's laboratory (7 by 10.3 m.) and a large store room (6.2 by 7 m.) on the upper floor. A store room (6 by 9 m.) of one story with overhead passage way for fishing gear, etc., connects this building to the main laboratory, formerly a private residence but remodeled for laboratory purposes. It is a three-story structure (9 by 16.2 m.) containing upon the ground floor three rooms serving as student laboratories, each with windows to the north, furnished with simple work tables, fire-clay sinks with fresh and salt water, an aquarium, dissecting tables (62 by 115 cm.) with glass tops formed of heavy panes of ribbed (beneath) glass set in cement, with rim on three sides and sloping to one corner with outlet for waste water. These rooms (3.7 by 4.4, 4 by 7, and 3.6 by 7 m.) have, facing the north, windows for eight students, but additional tables can be added. The central room contains a well-mounted and fully labeled collection of invertebrates and fishes representing the local fauna displayed in glazed wall cases. Upon this floor is a work shop (4.3 by 4.4 m.) with tool bench and water still.

On the second floor, the center of the building is occupied by the research laboratory (6 by 7 m.), with three places equipped with tables facing north windows and an abundance of accessory table space, fire-clay sink with fresh and salt water, glass-topped aquarium table, etc. A library of about 2,000 volumes of biological serials and monographs drawn from the university is kept permanently in this room. Upon either side of the room and upon the floor above are chambers, six in all, with accommodations for eight persons.

Two of these rooms are equipped with tables for microscopical work. The station has thus in all places for fourteen workers.

On the south side of the laboratory and connected with it is the engine room (2 by 2.8 m.) and water tower (4.3 m. in diameter and 7 m. high) with dark room fitted for photographic work beneath.

Adjacent is the acetylene house (1.5 by 2.15 m.) with the system "Le Claireur" for supplying gas to the station for light and laboratory use and the keeper's lodge of three rooms.

The pumping plant consists of a "Le Progrès" petrol motor of about 3 horsepower and brass pump with horizontal plunger. The sea pipe is a 6 cm. lead pipe passing to a point on the beach above low tide about 75 m. from the pump, where it opens in a cement block to which it is anchored. The water is carried by a 6 cm. lead main to the masonry reservoir (3 m. diameter and 2.5 m. in height with walls 0.3 m. thick) with a capacity of 11 cubic meters. The distributing system consists of lead pipes with mains 6 cm., laterals 3.2, and terminals 1.5 cm. in diameter. The cocks and valves are of brass.

The aquarium room, to which without charge the public is occasionally admitted, contains eight separate open aquaria on slate slabs resting on brick pillars (0.9 m. in height). The bases of the aquaria are formed by these slabs (2.5 to 4 cm. thick) in which are grooves (16 mm. wide and 20 deep) to receive the glass and the corner posts of angle brass (3 by 3 cm. and 2 mm. thick). The sides are of plate glass (8 mm. in thickness, set in ordinary Portland cement). The dimensions (in centimeters) used are as follows:

Dimensions of aquaria.

Length.	Width.	Height.
24	56	102
30	56	102
18	56	82
24	40	82
38	95	95

The aquaria are supplied by overhead spray delivered from an oblique glass pipette at a height of 20 to 30 cm. above the water level. The overflow is carried off from the surface by vertical glass tubes set in corks in the corner of the aquaria, discharging into 3 cm. lead pipes beneath, which in turn discharge in open channels in the stone floor. The water passes but once through the circulating system.

In this room are two floor tanks (2 by 2.3 and 2 by 3.7 m. and 45 cm. deep with walls 13 cm. thick) of brick, lined throughout with glass set in cement. The glass used is in panes 25 cm. square, ribbed beneath, and is of the sort employed in the lining of wine vats in France. These tanks are used as aquaria for fish and large inverte-

brates. They are supplied with overhead spray at a height of 0.9 m. and their outflow is from the bottom or surface and is regulated by an ingenious device with adjustable valve, as shown in the accompanying figure.

The perforated lead bulb is placed on the lower arm of the inner lead pipe for bottom outflow and on the upper for surface outflow, the orifice not in use being stopped with a cork.

The aquarium room is also provided with large dissecting table (0.8 by 2 m. and 1 m. high), of stone, concaved toward the middle, with drain pipe and overhead water supply.

The Luc-sur-Mer laboratory has an ample equipment of glassware and chemicals and draws its supply of instruments, etc., from the laboratories at Caen. Its field equipment consists of a yawl, the *Nauplius*, 7 m. long, and a rowboat with the usual outfit of dredges and seines. It has several 4.5 m. beam trawls, traps, and crab pots, plankton nets, etc., and considerable assortment of implements for shore collecting.

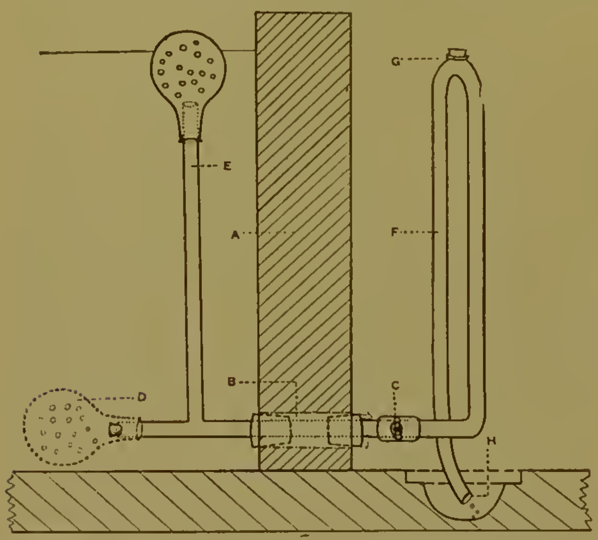


Fig. 10.—Siphoning device for floor aquaria at Luc-sur-Mer, shown in section: *a*, wall of aquarium; *b*, cana through wall; *c*, cock; *d*, perforated lead bulb (removable); *e*, standpipe for surface overflow; *f*, siphon; *g*. air valve, with screw; *h*, outlet into floor channel.

There is no harbor at the station, the nearest shelter in time of storm being found at Ouistreham, 6 km. distant. The beach at Luc-sur-Mer is sandy, with some pebbles and shingle, and wide stretches exposed at low tides with occasional patches of green algæ. The bottom in adjacent waters is sandy, with considerable areas of broken shells and mud and occasional rocky regions, affording fine trawling ground. The water is shallow, attaining a depth of 40 meters only at a distance of about 40 km., and the greatest depth available in the English channel opposite, near the station, is only 78 m.

Literature: Sand (1897).

ZOOLOGICAL STATION OF PORTEL.

Director, Prof. Paul Hallez, Laboratoire de l'Anatomie et de l'Embryologie Comparée. Rue Brûle-Maison, Lille, France. August–September, station Zoologique, Le Portel près Boulogne, Pas-de-Calais.

In addition one porter and collector.

In 1888, upon the transfer of Prof. A. Giard from the University of Lille to the Sorbonne at Paris, the station at Wimereux, which for fifteen years had been associated with the former university, was taken with its director into relations with the Sorbonne. Called to the chair at Lille, Prof. Paul Hallez set about establishing a station for the instruction of the pupils of the university in marine zoology, and selected a location at Portel about 2 km. south of Boulogne-sur-Mer upon the other side of the port from Wimereux, not far from the private marine laboratory of M. Bettencourt. (See Giard, 1889.) Here, on May 1, 1888, the station was opened in a rented cottage. In 1890 the facilities of the station were increased by the purchase of the *Beroe*, and in 1895, by agreement between the ministers of public instruction and public works, a site was secured for the station near the base of the great Carnot mole forming the outer shelter harbor at Boulogne. Finally, in 1900, the University of Lille voted the funds necessary for the construction of the building, and grants from the ministry of public instruction, the Society of Sciences of Lille, and the French Association, provided for the furnishing and equipment of the building. Research tables were founded by Profs. Ch. Barrois, E. Vaillant, and M. Lonquéty.

The station is attached directly to the University of Lille and is used primarily for the instruction of university students at the Easter and summer vacations and for the researches of the staffs of the departments of comparative anatomy and embryology and zoology. It is fitted accordingly for instruction in marine zoology. Research is, however, prosecuted actively at the station, over one hundred papers having been prepared in whole or in part by its aid, appearing in various biological periodicals of France and elsewhere. It issues no publications and carries on no established programme of exploration or investigation.

Its privileges are afforded without charge to all qualified students and investigators on application to the director, in so far as room permits. Material or the means of securing it are supplied and also the ordinary chemicals and glassware. Investigators should provide their own microscopes, however. Biological material for instruction or research is supplied at cost by arrangement with the director, but no regular supply department is maintained. A few furnished rooms are available at a nominal fee to the concierge of 2½ francs per week.

The station does not maintain any connection with the fisheries, but receives meager support directly through the university. It receives in addition much gratuitous service, and assistance from private funds enables it to carry on its work. Its annual expenditures are 3,000 to 4;000 francs.

The station is open in the Easter recess and in the summer vacation from June 15. It is attended annually by about twenty-five

students and five investigators. Its clientele is drawn not only from the University of Lille, but also from Belgium, Germany, and Switzerland.

The station is located at the eastern end of the village Le Portel, about 2 km. southwest of the entrance to the port of Boulogne-sur-Mer, immediately at the base of the great Carnot dike, which extends seaward for 2,150 m., forming a sheltering wall for the Port Nouveau. It lies close to the Petit Port upon a filled level area at the foot of the cliffs. It is reached from the village of Portel, where a conveniently located hotel is found, or by carriage from Boulogne via the Boulevard Chatillon to the water front.

The building (Pl. XXIX, *A*) stands a few meters from the water's edge in inclosed grounds containing 2,140 sq. m., about 3 m. above ordinary high tide. It is a plain rectangular structure (11 by 31 m.) of brick and plaster of two stories with tile roof. Its long axis runs northwest by southeast, and it is abundantly lighted by numerous windows. Projecting from the building from the landward side is the one-story aquarium room, with cement water tank above.

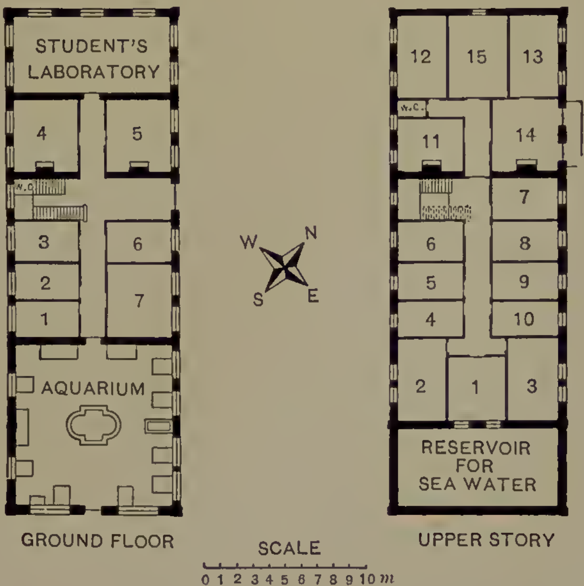
The ground floor (Pl. XXIX, *B*) has its main entrance on the long façade leading into a cruciform corridor, from which ascend the stairs to the second story. At one end the main corridor opens into a general student's laboratory (5 by 11 m.), lighted on three sides and providing places for eight or more students. At the other end of the hall is the large aquarium room (11 by 11 m.). Opening from the hall are a reagent room (2.5 by 4.5 m.) and private laboratories. One of the larger rooms serves as the director's office and laboratory. Upon the second floor are the modest quarters of the director and ten chambers simply furnished as lodgings for students.

Adjacent to the station is the two-story building (5 by 13 m.) containing the quarters of the keeper, storeroom (5 by 7 m.), and machine room (4 by 5 m.).

The general laboratory and research rooms are provided with fresh and salt water, are lighted by oil lamps, and two of them are heated by grates. They are simply furnished with wall tables, book and reagent cases, and shelving. The equipment for research and instruction is drawn from the laboratories at Lille. No museum or library is maintained at Portel.

The pumping plant consists of a 3-horsepower Crossley engine, with a centrifugal iron pump with lead lining. The water is drawn through an 8 cm. cast-iron sea pipe, 50 m. long, opening directly on the sea wall 2 m. below high tide. After flushing the sea pipe and pump, the water is pumped into a settling basin (4 by 6 m.) containing 60 cu. m., adjacent to the machine room. Thence it is pumped to the cement reservoir above the aquarium room (5 by 10 by 1 m.), containing 50 cu. m. This reservoir is roofed over with cement and supplies the aquaria and laboratories below. The mains are of 8 cm.

A. STATION BUILDING.



B. FLOOR PLANS OF STATION, AFTER HALLEZ (1909).

ZOOLOGICAL STATION AT LA PORTEL.

A. AQUARIUM ROOM, SHOWING FLOOR TANK AND AQUARIA TABLES.

B. AQUARIUM TABLE WITH THREE GLASS BASINS.

AQUARIA AT LA PORTEL STATION.

cast-iron pipe. The distributing system is of soft lead (5 and 2 cm.), with brass cocks. The terminals are of rubber tubing, with pinch cock and glass tips. The aquaria are provided with overhead spray and vertical standpipe, with surface run-off through inverted perforated cones of porcelain.

The aquarium room (Pl XXX, *A*) is abundantly lighted, the light being softened by paint upon the glass. It has a central floor tank in the form of a coupéd cross, with two ends rounded. Its extreme dimensions are 2.6 by 3.7 m. by 35 cm. deep, with central fountain and vertical standpipe for outlet at one side.

Aboût the periphery of the room are eleven aquarium tables of reenforced concrete (Pl. XXX, *A*), with tops 1 by 1.25 m. and 12 cm. thick and 0.9 m. from the floor. In the center of each is a fixed plate-glass aquarium (0.6 by 0.9 m., with sides 0.2 or 0.3 m. high), with the glass set in grooves in the cement top and in slotted bronze angle posts (2 by 2 cm.) at the corners. The glass is 4 and 8 mm. in thickness and is set in minium cement. In addition there are three tables (0.9 by 2.25 m. and 5.5 cm. thick) of reenforced concrete for movable glass aquaria (Pl XXX, *B*). There are three glass tanks (42 by 60 cm. and 18 cm. deep), with outlets let through the corners. There is also a cement sorting tank (0.9 by 1.7 m. and 1.05 m. high) in the form of a cement tray, with sloping bottom, 20 cm. deep at one end and 7.5 at the other. The aquaria are all independent, and the water is used but once.

This aquarium room is a model for excellent illumination and arrangement, ease of access and observation, durability and simplicity of construction of the aquaria.

The natural conditions are not unlike those at Wimereux in the main. The great stone pier extending for over a mile seaward furnishes a rocky collecting ground, easily accessible at all times, of great extent, upon which a varied shore fauna finds attachment and shelter. Excellent and varied dredging grounds lie close at hand.

Full accounts of the fauna upon the dredging grounds will be found in the papers of Professor Hallez (1899) and complete lists ofseveral groups in his special summaries of the anemones (1890), nemertines, turbellarians, and a bibliography of other groups, with later additions in his faunistic notes.

Literature: Hallez (1890, 1899, 1909).

STATION AQUICOLE, BOULOGNE-SUR-MER, FRANCE.

Director, Dr. A. Cligny, station Aquicole, Boulogne-sur-Mer.
Telegraph address: Station Aquicole.
In addition, one keeper, one skipper, two engineers, and three sailors.

The decline of the fisheries on the northern coasts of France and the need of scientific assistance in solving many of the problems pressing

for solution led M. A. Huguet, senator of Pas-de Calais and mayor of Boulogne, to urge in 1881–82 upon a committee of the French Senate appointed to investigate the fisheries the establishment at this important fishing port of a fisheries research station. The movement finally resulted in government grants for the enterprise and its affiliation with the central fisheries bureau at Paris

The rapid development in recent years of the fishing industries at Boulogne, and the extension not only to the Faroes, Iceland, and Newfoundland, but also to the coasts of Africa, have made this city the foremost fishing port upon the Continent. The station has taken an important part in this progress by its investigations into the methods of fishing used elsewhere and into the technical matters of cold storage, and has recently greatly extended its facilities and projects for the technical instruction of skippers and engineers for the fishing fleet.

The station was founded in 1884, with Dr. E. Sauvage, assistant in ichthyology at the Museum of Natural History in Paris, as director, and remained under his direction for a decade. In 1892 Dr. J. Canu became assistant at the station, and in 1894 was made its director, retaining the post till 1902. In 1900 Dr. A. Cligny, of the Paris Museum, was made assistant at the station and in 1903 succeeded Doctor Canu upon his retirement.

Its object has been from the first the investigation of the immediate practical problems of the fisheries rather than any general programme of biological investigations. It is not connected with higher institutions of learning and only indirectly serves the cause of scientific instruction and research by providing field excursions and occasional collecting trips on its boats for students and investigators at the neighboring stations of Wimereux and Portel.

It has, however, close affiliations with the local technical schools, the "École pratique d'Industrie" and the "École d'Hydrographie," adjacent to the station. It provides upon its boats practical instruction each year for some seventy lads from the training school, who are preparing to become marine engineers and firemen. The "École d'Hydrographie," established in 1909, is designed to train men as skippers for fishing and commercial boats. Instruction in practical navigation, the manipulation and management of fishing gear, and in the practical and technical phases of salting, curing, cold storage, and marketing of fish is given in this school, and the facilities of the station will form a part of its equipment, while its boats are used in its field work.

The director is an attaché of the Service Scientifique des Pêches Maritimes, in charge of the district from Calais to Brest, and the station is located in the "Laboratoire départemental du Chimie, agricole et industriele de Boulogne-sur-Mer." The station is sup-

ported entirely from state funds, receiving an annual grant from the ministry of agriculture of 2,000 francs and from the ministry of the marine of 3,500 francs for upkeep. In addition there are allotments for salaries to the amount of 7,600 francs and for the upkeep of the boats of the station of 16,000 francs per annum. Of the latter sum 7,500 francs is paid for wages, 3,000 francs for coal, and the balance for equipment and repairs.

The station has supervision of the coast fisheries and the oyster parks, especially in the matter of sewage pollution on the north coast of France, and conducts special investigations on fishery problems, as, for example, on the effect of shrimp fishing at different seasons of the year, upon the supply of young fish, and on the methods and results of cold storage as applied to the sea fisheries. It also carries on some investigations on the plankton and on the development of the food fishes. It offers no facilities for research to outsiders. The results of its investigations are published in the Annales de la Station Aquicole (vols. 1–2, 1892–1894, N. S. V.; 1–2, 1905–1909), issued at the expense of the director.

The station is located on Boulevard Chatillon, a few minutes' ride by tram from the central railway station in the "Laboratoire départemental de Chimie," adjacent to the new port. It occupies five rooms on the second floor of this building for its office, laboratory, and collections, and several rooms on the ground floor for stores and its fresh-water fish hatchery. It is not supplied with salt water and contains no aquaria other than those used in the hatchery. The collection contains a full representation of the fishes of the channel and many invertebrates and a collection of charts illustrating statistics of French fisheries, especially those of Boulogne for many years past. The station possesses a simple laboratory equipment for fisheries work and a small hatchery for rearing the fry of *Salmonidæ.* It has also a Fabre-Domergue rotator for sea-fish eggs, but does no sea-fish hatching.

The station has a fishing steamer (see Cligny, 1909), *La Manche*, built in 1907 especially for the purposes of technical instruction and research. She is a stout wooden steamer of 96.76 gross tonnage, built on the lines and with the rigging of the Boulogne herring boats, with a length of 26 m., beam amidships of 6 m., and draft astern of 3.1 m. She has two masts, with full equipment of sails, and a compound condensing engine of 147 horsepower, and can make 8.5 knots per hour. Her bunkers carry 18 tons of coal, sufficient for eight days' steaming at full speed. She carries a crew consisting of one captain, two engineers, and three sailors, with supplementary aid from the pupils of the fisheries school. To provide for these pupils her engine room is unusually large, and bunk room forward is provided for fifteen boys. The boys, 15 to 18 years of age, are taken from the school in lots of

fifteen and are given practical instruction at sea in short cruises of two or more days.

The boat has aft of the large forecastle a fish hold the width of the ship, 2.35 m. in length, large enough to receive 100 barrels of fish. Amidships and also extending across the ship is the live well or vivier 3.8 m. long, with a surface of 20 sq. m. and a capacity of about 11 cu. m. The well communicates with the sea, and the circulation is insured by connecting the pump of the condenser with the well, giving a circulation of about 20 cu. m. per hour. Planking above the water level affords access for examination of the contents of the well and also serves to reduce the swash of the water in a heavy sea.

Above the live well and upon either side of its opening are two compartments (1.9 by 3.8 m.) communicating forward of the live-well hatch, which serve as laboratories for the scientific work. The light through a side port is insufficient for many kinds of laboratory work.

The engine room (7 m. in length) is separated from the live well by water-tight partition and double air spaces, with special protection against the transmission of heat. Aft of the engine room is the cabin for the skipper, instructor, and engineers, and that of the director. The boat is specially planned to conform as nearly as possible to the type of the small steam trawler, in order to familiarize the pupils as far as possible with the boat, machinery, and gear used by Boulogne fishermen.

The boat is equipped with a 6-horsepower steam winch and two lengths of galvanized steel cable one-half inch in diameter and 120 fathoms in length for trawling, and 100 fathoms of 4 mm. cable for hydrographic and plankton work.

She carries commercial otter trawls and drift nets, two half-size Petersen young-fish trawls, two reversing thermometers, a Nansen-Pettersson insulated water bottle, and silk plankton nets of Hensen and Cépède models. The station has also a motor boat (5 by 1 m.), the *Orthonecte*, with 7-horsepower Aster benzine motor.

Literature: Huguet (1882), Cligny (1909)

ZOOLOGICAL STATION OF WIMEREUX, WIMEREUX (PAS-DE-CALAIS).

Director, Prof. Maurice Caullery, Laboratoire d'Évolution des Êtres Organizés, 5 Rue d'Ulm, Paris, professor adjoint a la Sorbonne, Paris.

Préparateur, Dr. Casimir Cépède, Station Zoologique, Wimereux.

In addition, one keeper and laboratory servant.

Telegraph address: Station Zoologique, Wimereux.

The Wimereux station is a fitting memorial of Prof. Alfred Giard, its founder and director for thirty-four years, an inspiring teacher, an enthusiastic naturalist, and an investigator of wide interests and deep insight into the fundamental evolutionary significance of the problems of biology. Called in 1873 to the chair of natural sciences

at the university at Lille, he established in the following summer a seaside laboratory for himself and his pupils at the most convenient point upon the neighboring coast, Wimereux near Boulogne-sur-Mer. For twenty-five years this station was maintained in a rented cottage located at the western side of the now filled in and ruined harbor of Wimereux excavated in 1803 by Napoleon. At the Easter recess and in the longer summer vacation Professor Giard and a small group of eager students were always found here hard at work in the intimate association of master and pupil which the cramped quarters and meager facilities of the enterprise necessitated. But there were compensations, for the stimulus of this close association made the Wimereux station one of the most productive centers in France and, as at that time there gathered at Marseille in the little laboratory of Marion a group of investigators and students imbued with Darwinistic ideas, so at Wimereux, about Giard, the devotees of the new ideas sought to interpret the facts of morphology and development in the light of the evolutionary principles. It was a period of great productivity, to which the pages of the "Bulletin scientifique de la France et de la Belgique" of which Giard was editor, bear witness. In 1887 the director was called to the École normale supérieure in Paris, and in 1889 to the Sorbonne to the chair d'Évolution des êtres organisés, and the laboratory at Wimereux became an annex of the University of Paris attached to that chair.

In 1890, by decree, the abandoned tower of Ambleteuse, Fort Mahon, was turned over to the minister of public instruction for the use of the laboratory, but could not be utilized in the absence of funds considered necessary for repairs and rebuilding the plant for protection against the inroads of the sea and for laboratory purposes. Fortunately a public-spirited friend of the laboratory, M. Lonquéty of Boulogne, came to the rescue and upon the occasion of the meeting of the French Association at Boulogne in 1899 offered to build and furnish a laboratory and cede it to the Sorbonne in return for the dismantled fort. This gift of 72,000 francs, disguised in the form of an exchange, equipped the institution with a picturesque though ill-adapted building containing laboratory, aquarium room, lodgings, and director's residence, and a further gift from the same source in 1908 of 10,000 francs provided for the erection of a part of the wing designed for the collections.

Upon the death of Professor Giard in 1908 the directorship of the station passed to the hands of his pupil and successor, Prof. Maurice Caullery, the present director.

The station at Wimereux is directly attached to the chair d'Évolution des êtres organisés, of the Sorbonne, and the director and staff are appointed in the manner usual in the University of Paris. There is no board of administration, the organization being simple and the

responsibility direct. The director is usually resident at the station in vacation seasons and the preparator is in continuous residence.

The staff is paid by the university and receives no special salary for its relation to the station. The station receives an annual grant of 6,000 francs in the university budget. Of this 1,200 francs are paid for service and 4,800 francs for upkeep of the building and grounds and for equipment. The publications are the private property of the editors or authors and are not an expense to the station.

The Wimereux station is an institution of higher instruction and research. Student excursions go to the station for the Easter vacation, and advanced students and investigators throng to it in the summer vacation during which advanced instruction adapted to the available material and to the needs of the individual student is given. It is open throughout the year to properly qualified investigators upon application to the director at Paris. No fees are charged, workers are provided with a laboratory table, with the necessary glassware and reagents, and the implements for collection of material. Microscopes and physiological apparatus are not furnished and expensive reagents or large quantities of reagents or containers are supplied at cost.

The laboratory has seven furnished chambers which are placed at the disposal of investigators at a charge of 10 francs per month or 2.50 francs per week. A comfortable hotel and a restaurant close by the laboratory and abundant tourist accommodations in the adjacent towns of Ambleteuse and Wimereux are offered.

On account of climatic conditions the winter months are unfavorable for field work at Wimereux. The station is usually full from July to October and at the Easter recess. It is frequented especially by French and Belgian students and investigators but guests from other European countries are not infrequent. Half-fare rates on the railroad to Wimereux or Boulogne-sur-Mer are granted to persons going to the laboratory on advance application to the director at Paris.

Investigators are free to work in whatever field they choose and to publish their results as they will. By special arrangement with the director papers may appear in the "Bulletin scientifique de la France et de la Belgique" or in the "Travaux de la Station Zoologique de Wimereux." The latter series contains more extensive monographs published at the author's expense. No special biological supply department is maintained at Wimereux, but collecting for research and instruction is freely permitted.

The station has no obligatory relation to the fisheries but by special arrangement may undertake the investigation of special problems. Cordial relations exist between it and the Station Aquicole at Boulogne-sur-Mer and naturalists often utilize the field trips of the

steamer at the Boulogne station for their collections. The station has no special programme of investigation. Many important investigations of morphological, embryological or monographic character have been carried on with its aid. At present the assistant naturalist, M. Cépède, is conducting seasonal observations upon the plankton, especially the phytoplankton.

Coincidently with the foundation of the station, Professor Giard undertook the editorship of the "Bulletin Scientifique de la France et de la Belgique" (vol. 42 in 1909), and much of the work done here has appeared in its pages. Upon his death it passed to the editorship and ownership of a board of editors, including the present director, Professor Caullery, and other pupils and friends of Professor Giard and the Wimereux station. An independent series, "Travaux de la Station Zoologique de Wimereux" (including originally those of the "Institut Zoologique de Lille), contains the more extensive or monographic papers issued at irregular intervals, No. 8 appearing in 1900.

Wimereux is a small seaside resort between Boulogne and Calais, reached in three to four hours from Paris or four to five hours from London. It is 6 km. north of Boulogne, with which it is connected by both rail and tramway. The station is located at the edge of the dunes, 2 km. beyond Wimereux. From the terminus of the Boulogne-Wimereux tramway an automobile service (train Renard) is operated several times daily to Ambleteuse and Wimille, passing the station.

The station stands at the sea front about 100 m. from the boulevard to Ambleteuse in rectangular grounds containing 2,500 sq. m. Its elevation above high tide is about 8 m. and the building stands about 12 m. from the concrete sea wall built to protect it from disastrous erosion by the sea, which is encroaching upon the cliffs in the locality. The building, designed by the government architect, M. Louis Bonnier, after plans by Professor Giard, is an effective piece of architecture, with gables, chimneys, and tower of gray stone and red tile roof. The plan of the building in its entirety contemplates a U-shaped structure, with central garden open to the east between the wings. The north wing, with its long axis running east and west, is the main laboratory building, three stories in height, with included water tower. Joined to this on the base of the U next the sea front are two connected but independent dwellings, one (4 by 8 m.) of two stories, with shop (*At.*, 4 by 5 m.) and storeroom (*R*, 3 by 4 m.) below (fig. 11) and the three rooms of the keeper's quarters (*L. G.*, fig. 12) above; the second is the director's residence, of irregular outline and extreme dimensions of 8 by 10 m., with cellars on the ground floor (*T*, fig. 11) and five modest rooms (*L. D.*) in the two stories above.

The other arm of the U was partially constructed in 1908, the terminal portion (4.5 by 10 m.) being erected as a beginning of the

museum. This contains four small rooms and the stair and will be used for the display of the Bettencourt collections.

The main laboratory building (10 by 19 m.) (Pl. XXXI, *A*, figs. 11 and 12), with the thick-walled water tower (*P*. and *N*., 3 by 5 m.) set partially into it in the angle between it and the keeper's lodge, forms an independent building. In the base of the water tower is a machine room (*N*, 2.8 by 3.3 m.) connected with the shop. Above it in the second story is the dark room (fig. 12, *P*), entered from the chemical laboratory, while on the third floor is the reservoir, with terrace and flagstaff above it.

The ground floor (fig. 11) is entered from the garden by a centrally located vestibule (*V*, 4 by 4 m.), with stair to the rooms above.

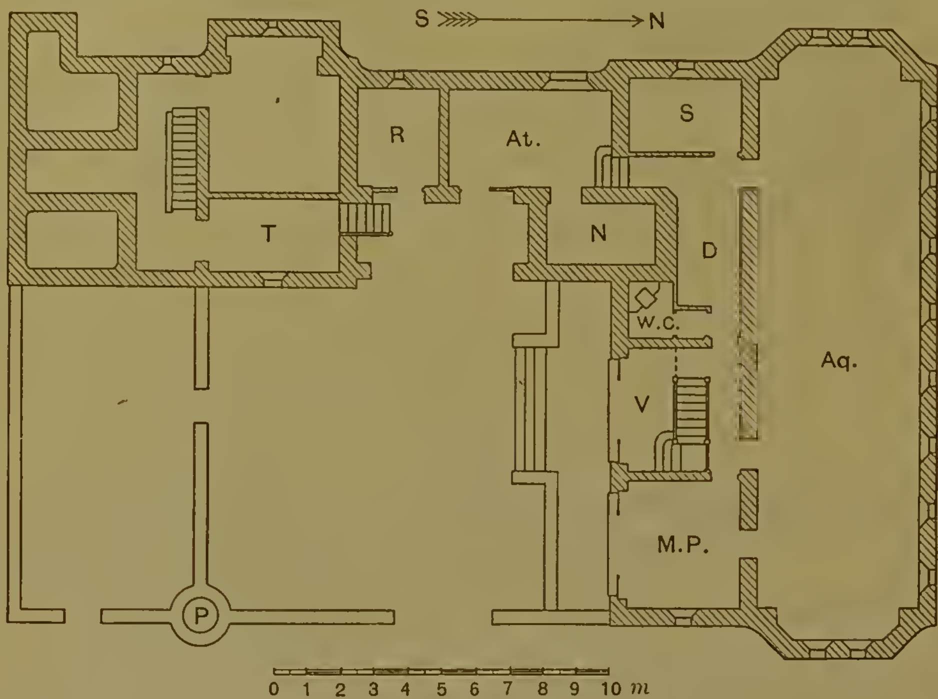


FIG. 11.—Basement floor, zoological station at Wimereux.

Above the door is the legend "Université de Paris, Faculté des Sciences, Station Zoologique." The corridor storeroom (*D*, 2 by 4.5 m.) leads to the dressing room (*S*, 2.3 by 3.5 m.), with lockers and shower bath, a useful adjunct after collecting trips on the beach or the popular diversion of an afternoon dip in the surf. A large tackle room (*M*, *P*, 4 by 4 m.) opens directly upon the terrace of the garden. The main part of this floor is occupied by the aquarium room (*A*, 6 by 19 m.), lighted by numerous small windows set high in the walls.

The second story (fig. 12) contains the main laboratory (*A*, 6 by 19 m.), lighted by double windows at the ends and a row of eight on the north face, each a meter in width, with large panes. Across the two ends and in front of the windows is a shelf table (53 or 73 cm. wide).

A. STATION BUILDING FROM THE EAST.

B. INTERIOR OF GENERAL LABORATORY.

ZOOLOGICAL STATION AT WIMEREUX.

From this there project into the room at regular intervals short tables (55 by 84 cm.), with open shelving above running at right angles to the wall and thus forming eight open cubicals (Pl. XXXI, *B*). These are models of compactness, the floor space allotted to each being about 2.2 sq. m., with at the same time abundant table space and ample shelving within easy reach of the worker. Through the center of the room are two racks for aquaria and glassware, each 6.1 m. long and 1.65 m. in height, with shelves 40 cm. wide, one of which is covered with sheet lead. The two uppermost shelves have slat tops to permit drainage. The highest shelf is but 32 cm. in width. Against the rear wall are a large fireplace, an upholstered settee, large banks of shelving for glassware, etc., and glazed sinks with fresh and salt water in the corners of the room. The glazed tile floor, light walls, abundant

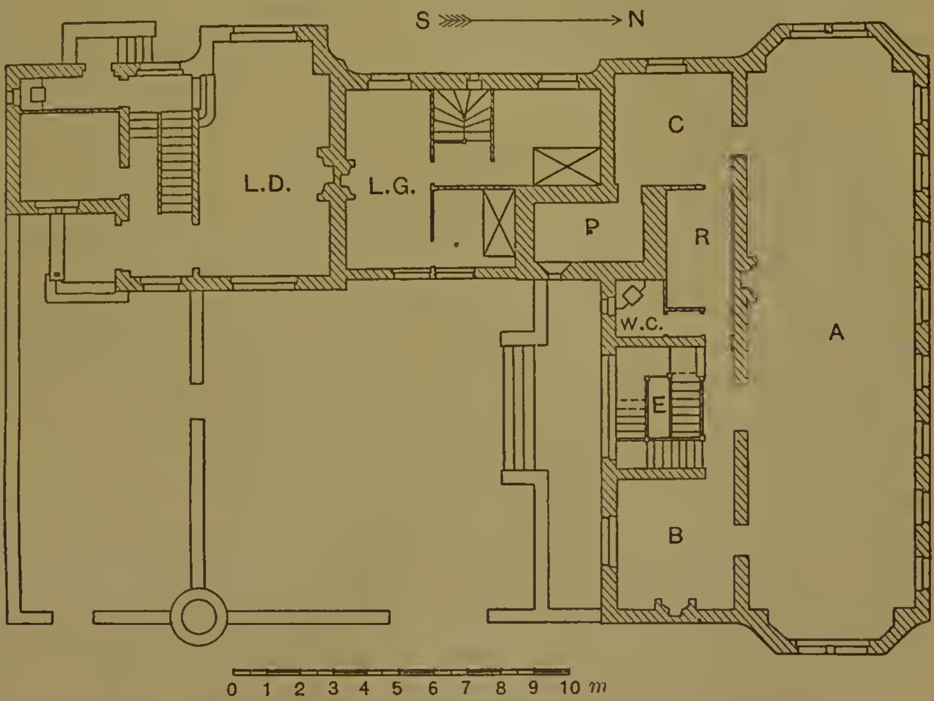


FIG. 12.—First floor, zoological station at Wimereux; after Menegaux (1905).

windows, and neatly finished woodwork give this laboratory a cheerful and bright appearance. The fittings are all made up by bolting the parts together to avoid damage by water and also to facilitate repairs or changes. Adjacent to the main laboratory are the chemical experimental room, (fig. 12, 3.2 by 3.7 m.), the reagent and glassware storeroom (*R*, 2 by 3.5 m.) and library (*B*, 3.7 by 4 m.), with glazed cases, chests of drawers, and reading table. A bust of Charles Darwin stands in the alcove above the hearth.

In the third story are seven chambers simply furnished for the lodging of workers at the laboratory. They may also be used as laboratories, affording window space for eight workers. The laboratory will thus accommodate in all a score of students or investigators.

The main laboratory and several of the chambers are provided with grates for heating. The building is lighted by oil lamps and is piped for fresh water from the cisterns of the laboratory. The salt-water circulation is not as yet installed.

The laboratory is well supplied with glassware and reagents, is provided with a Gram rocking and Minot rotary microtome, paraffin ovens, a Zeiss-Greenough microscope, Zeiss apochromatic and a Stiasny microscope. The library contains about 300 volumes of selected works, general treatises, monographs, and papers bearing on the local fauna and flora, and may be supplemented on demand by books from the library of the Laboratory of Evolution at Paris. The collections illustrating the fauna and flora of Boulogne and vicinity are most excellent and are fully labeled in most cases. They include the extensive collections made by Doctor Bettencourt, who for a number of years maintained at his own expense a marine research laboratory at Portel (see Giard, 1889) and made large collections along the coast, especially of hydroids, sponges, and bryozoans. There is also a collection of mollusks (marine, fresh water, and terrestrial), of algæ, and of mushrooms. The fauna and flora of the adjacent dunes and of brackish and fresh waters are also represented as a result of the labors of the founder of the station.

The station has as yet no pumping plant or salt water circulating system, all salt water for use in the aquaria and laboratories being brought into the laboratory by hand. The aquarium room is, however, fitted with two banks of aquaria built of concrete in the form of a series of arches supporting a row of tanks above and containing beneath each arch a floor basin. The banks are 5 m. long and 0.5 wide and 1.45 and 1.65 m. in height at the ends, and each supports a series of six of decreasing length and height. The aquaria are all 0.5 m. wide and measure in length and height, respectively, 93 by 45, 77 by 37, 77 by 34, 73 by 31, 68 by 28, and 60 by 24 cm. and have plate glass sides 6 mm. thick. Beneath each arch is a cement floor tank (0.5 by 1.15 and 0.4 m. deep). Both aquarium and floor tanks are provided with removable covers of glass or wire netting. At the ends of the room are two large cement floor tanks, one of semicircular form (2.5 by 2 m. and 1 m. high), with dish-shaped bottom; the other 2 by 2.2 m. and 0.8 m. high, with walls 25 cm. thick, lined with opal glass. Through the middle of the room are two long aquarium tables (0.8 by 3.7 and 0.9 m. high) of bolted woodwork, with top containing two rows of open slatwork made of oak pieces 3 by 3 by 25 cm., set in the planking margin and axis. The room is provided with glass jars and boxes for aquaria and with Coste fish-hatching troughs of yellow crockery ware.

Owing to the absence of a harbor at the station, only such boats can be kept as can be beached. The station has at present only a

stout sailboat 3.5 m. long. The field equipment consists of small dredges, trawls, and plankton nets and an excellent outfit of bars, hooks, nets, and spades especially made for shore collecting among rocks, tide pools, and on sandy beaches.

The environmental conditions at Wimereux are not unlike those at Luc-sur-Mer and Portel. The great amplitude of the tides, attaining 11 m. at spring, exposes wide stretches of the shore. Adjacent to the station a rocky reef, with zones of *Enteromorpha*, *Fucus*, and *Laminaria* and numerous tide pools afford a superb collecting ground for the littoral fauna. Wide flats of sand and shingle are also available, and mud flats are found at Boulogne. A small stream, the Ruisseau des Oiës, near the station, provides convenient access to the fauna of brackish and fresh water. A very full account of the local fauna will be found in the papers of Giard (1899, 1899a).

Literature: Giard (1889, 1899, 1899a), Menegaux (1905), and Caullery (1907, 1908).

BIOLOGICAL STATION OF AMBLETEUSE (PAS-DE-CALAIS).

Director, Prof. Charles Maurice, Laboratoire de Zoologie, Université Catholique de Lille, Lille, France. Ambleteuse, Attiches, par Port à Marcq (Nord). At Ambleteuse, August–September.

Chef-des-travaux pratiques, M. l'Abbé R. Schodduyn.

Telegraph address: Station Biologique Ambleteuse.

Several kilometers beyond the station at Wimereux is the "Station Biologique d'Ambleteuse" of the Catholic University at Lille, founded in 1894 by Prof. Charles Maurice. It is supported by the Catholic University of Lille, to which it belongs, and by private gifts. It is used primarily for instruction of vacation classes on excursions from the university at time of equinoctial tides and for research. It is open throughout the whole year to students and investigators without charge. About 20 students and 10 investigators are in attendance each year.

The station is located in hired buildings, a small chalet providing several research rooms, chemical laboratory, dark room, and furnished rooms for students. The main laboratory is a long, well-lighted hall adjacent to the chalet, with long tables facing the windows, providing places for twenty workers. A central row of aquaria is provided in this laboratory. The installation of a pumping plant and circulating system is planned in the near future.

The station has a small working library, a few microscopes, and a microtome and is equipped for vacation classes from the laboratory at Lille.

Literature: Maurice (1899).

THE LIMNOLOGICAL STATION AT BESSE-EN-CHANDESSE AND THE FISH-CULTURAL LABORATORY AT CLERMONT-FERRAND (PUY-DE-DÔME).

Director, Prof. Charles Bruyant, École de Médecine, 9 Rue du Port, Clermont-Ferrand (Puy-de-Dome), France. November to July; the rest of the year at Besse-en-Chandesse.

Secretary and editor of the "Annales," M. G. Dufour.

Superintendent of laboratory at Clermont-Ferrand, M. Thomas.

Superintendent of station at Besse, M. Julian Lacombe.

Preparator of station, M. A. Pouzols.

Founded in 1893 by Prof. Paul Girod in the interests of limnology and pisciculture in one of the most picturesque spots on the "roof of France," the station at Besse was the first fresh-water station in France and one of the oldest in Europe. It was not until 1906 that the station was moved from its temporary quarters in the communal school at Besse to its present permanent building and came under the directorship of Dr. Charles Bruyant, the limnologist of Clermont-Ferrand. In 1908, in connection with the meeting of the French association at Clermont-Ferrand, its work was placed on a permanent basis and greatly extended. The station has from the outset been intimately connected with the zoological laboratory of the university at Clermont-Ferrand.

It consists at present of two parts, a laboratory of pisciculture at Clermont-Ferrand and a limnological station at Besse, the former engaged in the propagation and distribution of fish and the latter, primarily, in scientific investigation. A fish hatchery, a botanical garden, and a meteorological station are maintained at Besse in connection with the biological station.

The station, originally supported by the Faculty of Sciences at Clermont-Ferrand, is now maintained by the "Service départemental de Pisciculture du Puy-de-Dome," receiving from it an annual subscription of 9,500 francs and an additional 200 francs from the commune of Besse.

The station is open without charge to competent investigators on application to the director. The station is located about 400 m. from the main "place" of the village of Besse, "a curious and very ancient little town" where accommodations may be secured. The station is open for work during the summer months only.

The station carries on regular explorations of the score or more alpine lakes in the neighborhood and conducts excursions from time to time to points of interest. Work upon the local fauna and flora, upon the quantity and distribution of the plankton and upon the physical conditions of the lakes, including the measurement of seiches, is carried on by the staff of the station. The researches of the station are published in a quarterly series, the "Annales de la Station Limnologique de Besse," instituted in 1909.

The station distributes over 500,000 salmonids yearly to the waters of the neighborhood and controls two of the lakes for the purposes of fish culture. A part of the output is sent to Clermont-Ferrand for early hatching and distribution to the warmer waters at lower altitudes while the remainder undergoes the slow hatching process normal to colder alpine waters (10°).

Besse is a remote mountain village lying on a tributary of the Dordonne about 50 km., in a direct line, southwest of Clermont-Ferrand. It may be reached by carriage, about 35 km., from Issoire (nine hours from Paris on the Paris-Nimes line) or by a picturesque mountain drive of about the same distance from the famous health resort, Mont Dore (twelve hours from Paris).

The station is located in a modest stone building of two stories immediately upon a mountain stream, the outlet of Lake Pavin, which supplies the water for the hatchery. It contains a limnological laboratory, supplied with running water by a hydraulic ram, and a fish-cultural laboratory in the basement, protected by double walls from freezing in winter and traversed by water from the stream. Six cement basins within the building are supplemented by out-of-door basins. The brook water is passed to a sedimentation basin, there filtered through sponges, and thence to the banks of hatching troughs of the ascending current type.

In addition to the laboratories the station building contains the workrooms and lodgings of the staff, a photographic dark room, and two chambers for visiting naturalists.

The limnological laboratory has a biological equipment and a field equipment consisting of plankton nets, sounding instruments, a Bruyant horizontal plankton net and a recording seiche indicator, Secchi disks, etc. Aquaria with running water and a compressed-air supply are provided. Large collections of plankton of local waters, and types of the local fauna and flora are found in the museum.

The station is located at an altitude of 1,000 m. in the midst of a region of alpine lakes, twenty-one lying in the field of operations at altitudes of 430 to 1,250 m. A full account of the local conditions and fauna and flora will be found in a paper by Bruyant (1904). It is a region rich in mountain streams and lies about 20 miles from the famous thermal baths of Mont Dore. It offers a quaint and charming environment, rich in waters of varied characters.

Literature: Bruyant (1896, 1900, 1904), Girod (1893), Poirier et Bruyant (1906), Ward (1900).

STATION FOR FISH CULTURE AND HYDROBIOLOGY OF THE UNIVERSITY OF TOULOUSE.

Director, Prof. Louis Roule, Laboratoire de Zoologie, Faculté de Sciences, Allies St. Michel, Université, Toulouse.

Superintendent, M. J. Audigé, Chef de Travaux, Laboratoire de Zoologie, Université, Toulouse.

In addition, two attendants.

Originally a commercial enterprise established for the culture of fish in "Bassins" for anglers from the city of Toulouse to catch, if they could, the rather elaborate undertaking finally passed into the hands of M. Antoine Labit, a wealthy lawyer of the city. His son, M. Georges Labit, was a man of wide travel with a personal interest in science as related to social amelioration. Impressed with the importance of fish culture as he had seen it in the Orient and deploring its low state of development in his native land, he conceived the idea of making of the undertaking a model culture plant, which should serve as an example for the people of the province, and developed it accordingly by establishing culture basins for native fish, by building up a museum of fresh-water fisheries and fish culture and by providing a lecture hall and an aquarium for popular instruction. His death, at an early age, in 1899, put a stop to the progress of the enterprise.

In the meantime Professor Roule had used the laboratory for some investigations and had given some lectures on fish culture in the hall. The interest aroused in the matter was so great that M. Labit in November, 1902, transferred to the University of Toulouse the entire establishment, with the buildings, reservoirs, canalizations, furnishings, and collections, stipulating only that it should be used for the advancement of fish culture, bear the name "Station de Pisciculture" and the statement that it was founded by Georges Labit, his son.

The council of the university accepted the gift and the transaction was later ratified by the President of the Republic. Since the formal transfer of the property in 1903 to the university, Professor Roule has been the director of the station, and associated with him in the practical management and improvement of the station has been his "chef de travaux," M. Audigé. In the spring of 1908 the new salmon-culture plant, erected at an expense of 40,000 francs, was completed. The estimated cost of the original plant is 250,000 francs.

The station is located about 3 km. from the center of the city on the left bank of the Garonne, in the suburbs of the Faubourg Saint-Cyprien at La Croix de Pierre at Nos. 5 and 13 Avenue de Muret and is easily reached by tram from the university.

The station is a direct dependency of the University of Toulouse, and its staff are members of the staff of the department of zoology in the university. Its affairs are controlled by the director who is professor of zoology at the university and are supervised by a "Conseil du perfectionement" of ten members of which the director is chairman, consisting of representatives of the university, eminent fish culturists, and the chief of the hydraulic service. The functions of this body are advisory.

The budget for 1909 was as follows:

Budget of Toulouse fish-culture station for 1909.

	Francs.
Receipts, subventions from—	
University of Toulouse	4,000
Department grants	1,100
Ministry of agriculture	2,000
Fisheries Society	1,000
Total	8,100
Expenses:	
Improvements	2,000
Service	2,400
Upkeep	2,450
Publications	400
Water	550
Collections	300
Total	8,100

The station is conducted primarily as a model piscicultural establishment, having for its function instruction in fish culture. For this purpose a course of seven public lectures is given in the spring of each year on the principles, methods, and apparatus for fish culture, with abundant illustrations from collections, hatching and culture ponds of the station. This course is open to all who can profit by it and is attended by 150 to 200 hearers annually. It is of the nature of university extension work rather than formal university instruction. The station also conducts a bureau for information and technical advice on the construction, installation, and operation of fish hatcheries, the care of culture basins, and food and diseases of fish.

The station keeps under culture a wide range of food fishes, primarily as a basis for instruction and information rather than for culture and distribution, though the surplus products of the station are distributed to waters of the vicinity and the mountain streams of the Pyrenees. The salmonids kept in cement tanks and reared each spring in the hatchery are the California rainbow trout (*Salmo irideus*), the brown trout (*S. fario*), the salmon (*S. salar*), and the brook trout (*Salvelinus fontinalis*). In the culture ponds are kept the bream (*Abramis brama*), goby (*Gobio fluviatilis*), tench (*Tinca vulgaris*), carp (*Cyprinus carpio*), perch (*Perca fluviatilis*), chevaine (*Squalius cephalus*), the frog, and crayfish.

The aquarium, museum, and grounds of the station are open to the public on Sunday afternoon for inspection.

The lines of investigation in progress at the station are the acclimatization of the salmonids to the warm waters of the lowlands, improved methods of hatching, feeding, and rearing fish, hybridization and the introduction of new forms, and an investigation of certain protozoan and bacterial diseases of fish.

Under the auspices of the station there is issued a quarterly "Bulletin Populaire (Revue générale, technique et pratique) de la Pisciculture et des Ameliorations de la Pêche," with the director of the station as editor.

The building is a plain two-story dwelling (6 by 36 m.) with the long façade upon a passageway and the other fronting upon the garden, which contains the culture basins. This building contains on the ground floor, in addition to the quarters of the keeper, the vestibule, a laboratory for the study of the physiology and pathology of fishes, public office, and an aquarium room (5.5 by 14 m.). The floor above contains a lecture hall (5.4 by 16 m) whose walls are adorned by an extensive collection of samples and illustrations of the implements and apparatus used in angling and in commercial fisheries. The room is arranged for stereopticon. A corridor, whose walls are hung with maps and charts illustrating the distribution of fresh-water fish and giving graphically the statistics of fish culture, leads to the museum (5.7 m. by 8.3 m.), containing a complete collection of the fresh-water fishes of western Europe, exhibiting their different races and their anatomical structure, especially those of taxonomic value. A second part of the collection exhibits the developmental stages of a number of species from egg to the adult, with a supplementary microscopical collection. There is also a representative hydrobiological collection of species of plants and animals related to fish culture as food or enemies of fish. The adjoining rooms serve as investigators' laboratories and are equipped for microscopical work and dissection.

Adjoining the main building of the station is the large new piscicultural laboratory (about 20 by 20 m.) equipped with cement hatching troughs of a new pattern. In the garden are the cement water tower with machine house beneath, the sheltered salmonid basins, the great reservoir, and the extensive culture basins.

The grounds of the station contain 11,788 sq. m., of which over three-quarters are at present occupied by the buildings and culture ponds. The water supply of the station is drawn from the terminus of an irrigating canal, the "St. Martory," which follows the left bank of the Garonne from the Pyrenees for a distance of 80 km. It delivers per hour to the station about 180 cu. m. of mountain water free from any contamination. The water is discharged from pipes from the canal 4 km. distant directly into a great reservoir (18.8 by 57.2 by 2.75 m. with a capacity of 2,800 cu. m.), which is contained within massive buttressed walls 3 m. in height. A smaller reservoir (4.1 by 60.9 by 22 m.) has a capacity of about 500 cu. m. From the reservoirs the water is carried to the aquarium room, to the culture basins, and to the river. The main reservoir serves as a sedimentation basin, whence the clear water is drawn off into the smaller reservoir, flowing out over rocky terraces to the culture basins below. It

also contains sufficient water to carry the plant during periods of repair to the canal.

The culture basins are 11 in number, with a surface area of about 8,000 sq. m. They are all sunk in the ground, with walls and bottom of cement. There are 11 rearing basins, comprising six long basins, four annular basins, and a model vivier. The last named is a large basin (9.9 by 39.8 by 2.3 m.) with one end harboring a sloping bank of water plants, with submerged tubs of water lilies whose leaves provide shade for the fish, and floating rafts of water cress and pots of gentles. This vivier is used for a demonstration pond for culture of carp, tench, and bream.

Adjacent to this are six long parallel basins (each 3.8 by 66.2 by 2.2 m. deep), between long lines of sheltering plane trees, each destined for the culture of a particular species of fresh-water fish. The four annular basins each surround an island 6 to 10 m. in diameter, are 3 m. in width and 1.75 m. in depth. One is used for fry of trout and perch, for pike and eels, a second for crayfish, a third for acclimatization experiments, and the last for frogs.

The salmonids are kept in sheltered cement tanks sunk in the ground and covered with wire screens. The tanks are supplied with water pumped from a well sunk into water-bearing sand strata.

The aquarium room is furnished with several score of aquaria of assorted sizes, a large floor basin, and rows of floor tanks. It is used for observation, experimental work, and work with fish diseases.

Literature: Roule (1904), Zacharias (1905).

FISH CULTURAL LABORATORY OF THE UNIVERSITY OF GRENOBLE (ISÈRE).

Director, Prof. Louis Leger, Laboratoire de Zoologie, Université Grenoble, Isère.
Dr. L. Perrier, Chef des Travaux, Université Grenoble.
Preparator, Dr. Ed. Hesse, Université, Grenoble.

Founded in 1901 by Professor Leger, this laboratory is intimately associated with the University of Grenoble and is essentially a laboratory for research and experiment.

In its organization, its relations to research and education, and to popular instruction this laboratory is remarkably similar to our own agricultural experiment stations associated with our state universities. Indeed it forms an excellent model for an aquicultural experiment station, uniting as it does scientific research of the highest order with laboratory experiment and field culture, and the practical instruction of foresters and others in modern scientific methods of fish culture. The advisory relation which exists between the station and the fish culturists of southeastern France is also similar to that which has arisen in agricultural matters between our experiment stations and the farming communities.

The activities of the station exhibit a happy combination of work in the fields of both pure and applied science. The rearing of considerable numbers of young salmonidæ affords material for the investigation of various questions of hydrobiology and ichthyopathology and for experimental improvement of the methods of fish culture. The lines of investigation followed are these:

1. The rearing and acclimatization of various salmonids in the experimental ponds (*Salmo irideus, Trutta fario, Salvelinus fontinalis* and *S. umbla*) are undertaken with a view to determining the best species for introduction into the various ponds, lakes, and streams, without detriment to the native trout (*Trutta fario*) and of extending the planting and culture of fish into new territory, both in high cold Alpine waters and the warm streams of the lowlands. Success has attended these efforts.

2. Streams are methodically examined throughout their course to establish their relative nutritive values and to determine not only their "capacité biogenique" but also the best regions for planting young fish. In this way useless planting, overplanting and underplanting are eliminated and greater returns for the outlay of time and money secured.

3. The intensive culture of different salmonid fishes in small areas is carried on in the experimental ponds.

4. The laboratory gives gratuitously to private individuals and fisheries societies information and advice regarding piscicultural matters and has thus been of great service in the active extension of pisciculture among landed proprietors in recent years. It also conducts an active propaganda in this direction, holding public institutes, with addresses and conferences, for the government agents of waters and forests, for fisheries societies, and others both at the university, and in neighborhoods where fish culture is practical or is possible.

5. The laboratory also conducts in conjunction with competent chemists investigations upon harmful industrial wastes in their relation to stream pollution.

6. Scientific investigations in ichthyopathology, with special reference to "Cancer thyroidienne" of the trout and the parasites of fishes and crayfish which are the cause of diseases, often of very destructive types.

The resources of the station do not provide research laboratories with facilities for many others than the staff, in fact, the scientific research is largely done as at the Fischereiversuchsstation at Munich, in close conjunction with an established laboratory to which students and investigators are admitted, in this case the zoological laboratory of the University of Grenoble. Students and investigators will find here, under the direction of Professor Leger, one of the most productive

centers in Europe in the study of parasitic protozoans, especially those of the lower animals.

The members of the staff of the station are all members of the staff of the zoological laboratory, and the entire annual budget of 2,000 francs, granted by the ministry of agriculture and the local department, is used in the maintenance of the experimental and fish cultural side of the work.

The station is located at Grenoble, 120 km. or two and one-half hours southeast of Lyon, and is compactly housed in the science building of the university. It occupies several rooms, one of 40 sq. m. used as a hatchery. This room is an admirable model of compactness and though small (4 by 7 m.) provides for the hatching and rearing through the early stages of growth of 30,000 to 40,000 salmonids yearly.

This room is carefully ventilated, has a supply of running cold water (11°) and is maintained throughout the year at a constant temperature of about 12° C. In the warmer (15° to 25°) research room the cyprinid fishes and the American sunfish (*Eupomotis gibbosus*) and catfish (*Ameiurus nebulosus*) are kept for experimental purposes.

The hatching is carried on in five batteries each of four troughs of the modified Coste type, each with a capacity of 2,000 eggs, and supplied with three to four liters per minute. These hatching troughs are of glazed yellow earthenware.

After hatching, the alevins are distributed to the low aquaria in the center of the room. Each tank (75 by 40 cm. and 12 or 18 cm. high) holds 2,000 to 3,000 fish and requires 3 to 4 liters of water at 12° C. per minute. The low sides facilitate the sorting of the eggs and attention to the aquaria. Minced spleen and curds are used as food. In two or three months the alevins are transferred to the larger aquaria (75 by 40 by 40 cm.) along the wall, where they rapidly attain the size (5 cm.) suitable for planting. Individuals reserved for breeding are kept throughout the year in larger aquaria (2 by 0.8 by 0.5 deep) containing 800 liters and supplied with 4 liters of water per minute by overhead spray. As many as 100 trout of 20 cm. length may be kept safely in such an aquarium. It is necessary, however, that the individuals in an aquarium should be about the same size to prevent cannibalism. Trout reared in these aquaria attain a weight of 1 km. in four to five years in spite of restricted quarters. Three long cement floor tanks receiving the overflow from the aquaria are used for storage of diseased fish, while the long cement floor tank (7 by 0.4 by 0.5 m.) below the aquaria along the wall serves for the large individuals used as breeding stock or for *Astacus* used in parasitological researches. Along

the opposite wall, below the aquarium shelf, is a narrow cement trough for running water in which *Gammarus* is reared for trout food.

The hatchery is also equipped with an amphibian cage, reservoir for rearing frogs and salamanders, and a series of small aquaria for the study of the nutritive value of various waters. The equipment also includes aerated tanks for the study of the action of industrial wastes upon the waters and fish of the region.

The piping throughout is of lead with brass cocks. The aquaria are fed by overhead sprays discharging from an elevation above water level of 20 to 35 cm.

In addition to the hatching room the station contains a laboratory of ichthyopathology and a museum, each with an area of about 20 sq. m. The museum contains a complete collection of the fresh-water fishes of France, models of their anatomy and stages of development, a unique collection illustrating the pathology of fishes, including an especially fine exhibit of thyroid cancer of the trout, and of the parasites of fishes. There is also a series showing the pathology and monstrosities of alevins and an exhibit of the apparatus for hatching and transport of eggs and alevins. Adjacent to the museum is a large lecture room used in the extension work of the station.

The research laboratory in ichthyopathology is combined in part with that of the zoological laboratory of the university and has the usual equipment of such institutions. In this room are the hydrobiological collections illustrating the fauna of torrents and alpine lakes, growth stages of fishes, and the enemies of fishes and their eggs and fry.

The field equipment of the station consists of a series of 5 experimental basins distributed at various altitudes (275 to 1,500 m.) and supplied with different types of water. Full records are kept of the number, size, and weight of the fish planted in these basins; and their rate of growth, quality of flesh, reproductive capacity, diseases, etc., are methodically determined, in conjunction with a physical, chemical, and biological study of their environments. In this way a scientific basis for a rational culture of the alpine waters of the neighborhood is being effectually demonstrated. A hatchery is attached to one of these field stations.

The scientific results of the station are published in various journals and those pertaining directly to problems of pisciculture are assembled and reissued in one or two fascicles annually under the title "Travaux du Laboratoire de Pisciculture de l'Université de Grenoble," the first fascicle appearing in 1909.

Literature: Leger (1908, 1909), Lefranc (1908).

THE FISH CULTURAL STATION OF BORDEAUX.

Director, Prof. J. Kunstler, Laboratoire de l'Anatomie Comparée et de l'Embryologie, Université, Bordeaux.

For several years past a local fisheries society in conjunction with Professor Kunstler has maintained an experimental station for fish culture whose aims are mainly practical.

ABANDONED STATIONS.

Several stations founded in earlier years in France have ceased to exist. These are the station of Fol and Barrois founded in the seventies at Nice, which was given up on the opening of the French station in 1880 at Villefranche, which in turn was abandoned after the cholera outbreak of 1882 and the opening of the Russian station at that place. In 1882 in connection with the aquarium of the zoological garden at Havre, a station, which was an annex of the laboratory of physiology at Paris, was opened with Professors Gibert and Paul Bert as directors. The station was discontinued on the death of Bert in 1886.

In the latter part of the eighties M. Ch. Bettencourt, a naturalist of Boulogne opened at his own expense a small laboratory at Portel, which, until his death, was hospitably opened to students and naturalists of the Wimereux station.

CHAPTER IV.

GREAT BRITAIN.

INTRODUCTION.

The direct support of biological stations by educational funds of local or state origin, often in connection with universities, so generally prevalent in other European countries, is almost wholly lacking in Great Britain. With the single exception of the Gatty Laboratory at St. Andrews, which is supported by the university, the biological stations of England derive only meager rentals of a few tables directly from university or educational funds. The stations have been forced, therefore, to turn to memberships of supporting societies composed to a considerable extent of scientific men themselves, to private benefactors, and to the commercial interests of the fisheries for aid. The result has been a relatively meager and fluctuating financial support, a large, but, fortunately, rarely predominating amateur, as over against strictly scientific control, and a relatively very large absorption of the funds and activities of the British stations in scientific fisheries work. The scientific fisheries work done by the British stations is unsurpassed in its excellence and effectiveness, and the popular features, such as public aquaria, elementary and technical instruction, are generally well developed, but the strictly scientific phases of the station's activities too often suffer for lack of adequate financial support and from consequent loss of scientific interest.

The oldest English station is that at Plymouth (1888), built and supported by private subscriptions and state funds, the fisheries having had from the start a large interest in its support and direction. About the same time the Puffin Island station (1887) was opened by Professor Herdman, to be succeeded in 1892 by that at Port Erin, and supplemented in 1896 by that at Piel-in-Barrow. The Puffin Island station, passing to the control of University College at Bangor, was discontinued in 1904. In all these enterprises of Professor Herdman, the popular, economic, and scientific interests have been happily combined. In 1897, in conjunction with the Northumberland fisheries committee, the station at Cullercoats was opened, and in 1902 that at Lowestoft for the prosecution of the work of the International Commission for the Investigation of the Sea, which also drew heavily

upon the strength of the Plymouth station for its investigation. The only fresh-water station in Great Britain, that at Sutton Broads, owes its origin and support entirely to private benefaction. For many years Mr. James Hornell maintained a private marine laboratory in a magnificent location on the island of Jersey (1893), but this was discontinued when Mr. Hornell took up the fisheries work at Ceylon in 1902.

The influence of the famous Challenger expedition and its able leader, Sir John Murray, has been felt profoundly in the development of biological stations in Scotland. The first station in Great Britain was founded in Scotland, at St. Andrews, in January, 1884, and a few months later the station at Granton was opened under the direction of Doctor Murray. In the following year a small field laboratory was opened by the fishery board for Scotland at Tarbert on Loch Fyne, and in 1888 a small laboratory was built in connection with the fish hatchery at Dunbar. The stations at Dunbar and Tarbert were subsequently closed and a new laboratory and plaice hatchery was opened later by the fishery board at Aberdeen. The institution at Granton was also short-lived, and its floating laboratory *The Ark* was sent in 1885 to the west coast of Scotland, where her presence led in time to the foundation of the Millport station, opened in 1897. The Challenger office and the Scottish oceanographical laboratory are the outcome, respectively, of the Challenger expedition (1873–1876), and the Scottish antarctic expedition, and are concerned, primarily, with the investigations of the collections made by these expeditions and the publication of their results. The "Survey of the Scottish lakes" is a scientific project without a permanent field laboratory.

While the economic factor has been helpful or dominant in the foundation of the stations at St. Andrews, Tarbert, Dunbar, and Aberdeen, the research feature has been prominent in all and is the main, if not indeed the sole, function of Scotland's finest stations at St. Andrews and Millport. Owing to defects in organization, the latter station has come, temporarily it is to be hoped, to serve popular rather than scientific interests.

In 1899 the Royal Dublin Society opened a marine laboratory for fisheries work in the 220-ton hull of the brigantine *Saturn*, which had been rebuilt into a floating laboratory. This was transferred in 1900 to the Irish fisheries bureau, which under the direction of Dr. E. W. Holt has done much excellent marine biological work in cooperation with the international commission. The Irish bureau maintains a fisheries station at Ardfry (1904). At Bangor, near Belfast, a small station is maintained in connection with Queen's College and the Ulster fisheries committee.

LABORATORY OF THE MARINE BIOLOGICAL ASSOCIATION AT PLYMOUTH, CITADEL HILL, PLYMOUTH, ENGLAND.

Director, E. J. Allen, D. Sc., The Laboratory, Citadel Hill, Plymouth, or Fisheries Laboratory, The Marina, Lowestoft; telegraph address, Laboratory, Plymouth.

Assistant director, L. R. Crawshay, M. A.

Assistant naturalist, A. E. Hefford, B. Sc.

Assistant naturalist, international investigators, A. J. Mason-Jones, M. Sc.

Hydrographer, D. J. Matthews.

Preparator, A. J. Smith.

In addition, an assistant, a preparator, a clerk, an engineer, a caretaker, and a boy.

The Plymouth biological station was indirectly the outgrowth of the International Fisheries Exhibition held in London in 1883. Public interest in the scientific investigation of problems relating to the fisheries was stimulated by this enterprise and resulted in a public meeting at the rooms of the Royal Society on March 31, 1884, at which Prof. T. H. Huxley presided, and as a result of the meeting a large and representative provisional council was appointed of thirty-seven members, including representatives of the Royal, Linnean, Zoological, and Microscopical societies, of the fisheries interests, and eminent British biologists, among whom were Professors Huxley, Lankester, Lubbock, Dallinger, Günther, Hooker, Foster, Ewart, Marshall, Moseley, Romanes, Sanderson, Sclater, Playfair, Sedgwick, Sladen, Sorby, Doctor Norman, and Mr. John Murray.

The council was formally organized with Professor Huxley as president, a long list of vice-presidents, and Prof. E. Ray Lankester as secretary, and a board of fifteen elective members. By June, 1886, a sum of £15,000 had been subscribed, including £5,000 from the Government. The striking feature of the subscription lists is the large number of individuals contributing. The largest gift (£2,000) came from "The Worshipful Company of Fishmongers" in London. The Clothworkers (£500) and the Mercers (£315) guilds also contributed, and the faculties and friends of the universities of Cambridge and Oxford each raised £500. The Royal (£250), Zoological (£100), and Microscopical (£100) societies and the British Association (£200) were also liberal givers. There were in all 26 gifts of £100 or over, aggregating £6,375, of which 10 contributions were from organizations and 18 from individuals. The remaining sum, nearly two-thirds of the total, was accumulated by small subscriptions. In all 384 organizations and individuals subscribed, including the individuals subscribing to the Cambridge and Oxford funds. Of these contributors over two-thirds had educational or scientific affiliations, such as membership in British scientific societies or university faculties, an epitome of the liberality of British scientists and a startling illustration of the limitations of support under which research labors in England, even when explicitly directed to a large extent,

as was the Plymouth station from the beginning, toward investigations of economic significance.

Mr. Heape was appointed resident superintendent during the period of organization and construction at Plymouth, which had been selected as the site of the station. He resigned in March, 1887, and Mr. G. C. Bourne, of New College, Oxford, was elected director of the laboratory and secretary of the association. In July, 1887, M. J. T. Cunningham, of the Scottish station at Granton, was appointed naturalist for fisheries investigations.

The building was formally dedicated June 30, 1887, though far from complete at the time, at a public ceremony presided over by Professor Flower, with addresses by Professor Lankester and others. The laboratory and its fittings were completed in 1888, at a cost approximately of £12,000. In August, 1890, Mr. Bourne resigned the directorship and was succeeded on November 29 by Mr. W. L. Calderwood, Dr. G. Herbert Fowler serving as acting director in the interim. In place of Mr. Calderwood, who resigned in 1893, Mr. E. J. Bles was elected to the directorship, remaining at the post till October, 1894, when Dr. E. J. Allen, the present director, was chosen to fill the position. In 1902 Dr. H. M. Kyle was appointed fisheries naturalist in connection with the Devon County council, giving one-half his time to instruction of fishermen. In 1902, upon the establishment of the International Commission for the Investigation of the Sea, the station at Plymouth was placed in charge of the English work by the Government, its staff enlarged, the steam trawler *Huxley* leased for the field work, and a field laboratory opened at Lowestoft. The council deliberately adopted the policy of throwing all the energies of the station into the prosecution of the international investigations, accepting the responsibility placed upon them by the Government, with the determination to place English fisheries science in a worthy place.

Dr. E. J. Allen was placed in charge as director of the investigations, with Mr. D. J. Matthews as hydrographer and Dr. L. H. Gough as assistant naturalist for plankton, with headquarters at Plymouth. The fisheries investigations at Lowestoft were in charge of Mr. W. Garstang, for many years associated with the Plymouth station in fisheries work, with Dr. W. Wallace as assistant naturalist for fishes, and Messrs. C. F. Cooper and R. A. Todd for invertebrates. With the single exception of the assistant naturalist at Plymouth, the entire staff of the Plymouth station have been assiduously devoted to the international investigations since 1902.

The English portion of the international scheme of hydrographic and plankton observations, the execution of which has been assigned to the Marine Biological Association, is carried out in the western half of the English Channel.

These investigations have for their object the study of the seasonal changes which take place in the physical and biological conditions prevailing over the entire area covered by the international programme, though more particularly directed to a study of the waters entering the North Sea from different directions. They are designed to determine (1) the origin, history, and physical and biological characters of the water found in each locality at different seasons of the year and at corresponding seasons in different years, changes in which must necessarily have a profound influence upon the distribution and abundance of the fish life in the sea; and (2) the variations which take place in the floating and swimming organisms (plankton) which constitute the fundamental food supply of the sea.

The investigation is carried on (1) by means of a series of quarterly cruises made simultaneously over the whole area by the vessels of the participating countries. As a result of these cruises, a thorough knowledge, based upon the most accurate available methods, is obtained of the conditions prevailing at all depths at certain fixed stations, together with a less detailed knowledge of conditions at intermediate points; and (2) by observations, more especially of the surface conditions, at as many points as possible during the time intervening between the seasonal cruises.

The seasonal cruises are carried out as nearly as circumstances allow during the first fortnights of February, May, August, and November, with a view to studying in detail the midwinter, mid-spring, midsummer, and midautumn conditions.

Originally twenty stations in the western half of the English Channel were worked on each cruise, but later the work has been extended seaward and northward into the Irish Channel by the addition of new points of observation. At each station the following programme of work is carried out:

Hydrographic and meteorological.—The temperature of the water at the surface is taken, and also, by means of the Pettersson-Nansen water bottle, with thermometers graduated to $\frac{1}{10}°$ C., the temperature at depths of 5, 10, 15, 20, 30, 40, 50, 75, 100, 125 m., and at the bottom.

Samples of water are procured at each of the above depths, and from these samples the salinity is subsequently determined in the laboratory by Volhard's titration method.

Observations of the temperature of the surface water are taken every two hours when running between the stations, and meteorological observations, including readings of the barometer and of the wet and dry bulb thermometer, are made at similar intervals.

Plankton.—Samples are taken with the following nets at each station:

(*a*) A vertical haul with a small Hensen net, the silk of which has 150 meshes to the inch.

(*b*) Hauls with the Garstang closing net, fitted with silk having 100 meshes to the inch, at 10 m., midwinter, and bottom.

(*c*) Surface gatherings with four ordinary tow nets having silk 26, 50, 100, and 150 meshes per inch, respectively.

The eight samples from each station are subsequently examined in the laboratory, all the species of plants and animals they contain being recorded, and the abundance of each indicated according to the system adopted by the international council.

Temperature records, water samples, and plankton collections are made regularly, at weekly intervals, at light-ships along the English and Irish coasts, and water samples are also collected by transchannel steamers and by fifteen or more transatlantic liners between latitudes 20° and 56° N., daily at noon on each trip. Weekly and fortnightly plankton collections are also made at Plymouth and in the channel. The regularity of the collections and the wide areas from which they come have resulted in the accumulation of data of great hydrographic and biological significance with reference to the circulation in the channel and North Sea and the relation of the Gulf Stream to the areas. The movements of swarms of certain plankton organisms from the Atlantic, through the areas under observation, have been traced with precision, and important relations between the movements of the mackerel and the distribution of particular types of plankton and weather conditions have been discovered.

The inclusion of fisheries work in the original programme of the Plymouth station and its assumption of the burden of the international investigations in 1902 have practically made it the scientific fisheries bureau for England. Its scientific output in this field has been large and of exceptionally high order.

The second part of the programme, scientific research in other fields of marine biology, has shown no corresponding growth, but has rather, in the absence of funds, adequate staff, and facilities, remained as a secondary feature of the station's work.

The Plymouth station was organized and is controlled by the Marine Biological Association of the United Kingdom, an organization consisting of governors (contributors of £500), founders (£100), life members (compounded at 15 guineas), and members (1 guinea per annum). Its affairs are conducted and laboratories managed by a council consisting of the governors, the officers (president, chairman of council, honorary secretary, and honorary treasurer), the prime warden of the Fishmonger's Company, and an elected council of 14 members chosen annually. Associate members are elected from among persons interested in fisheries and marine biology. They pay

no dues and have no share in the management of the association. Members are elected on nomination by the council.

The director of the station is elected by the council, acts as the secretary of the association and council, and prepares the regularly published reports of that body. The director has charge of the laboratory, aquarium, and library, edits the publications, and attends to the correspondence and general affairs of the association. With the removal of Doctor Allen to the Lowestoft laboratory, an assistant director was appointed in immediate charge of station matters at Plymouth.

The only administrative relations between the station and the educational institutions of Great Britain is the appointment of a governor by each of the universities of Cambridge and Oxford. Indirectly, as members of the association and council, the biological faculties of these and other English universities practically control the affairs of the association and the station. It is not without significance that the association has been intrusted with the direct control of the scientific fisheries investigations without the intervention of political administrators, other than parliamentary committees.

The support of the station is derived in part from government grants, private donations, dues of members, sales of supplies, admissions to aquarium, and rent of tables. For the year ending May 30, 1908, the income and expenditures were as follows:

Receipts and expenditures, Plymouth biological station.

RECEIPTS.

	£	s.	d.
H. M. treasury	1,000	0	0
Fishmonger's Company	400	0	0
Members	112	6	0
Rent of tables	85	2	0
Donations	40	0	0
Hire of steamers for international investigations	650	0	0
Loan	243	14	6
Sales of publications	10	2	8
Sales of specimens	400	10	6
Admissions to aquarium	134	10	11
Total	3,134	5	9

EXPENDITURES.

	£	s.	d.
Salaries of staff (3)	546	5	5
Employees and labor	687	13	0
Traveling expenses	53	10	2
Library	104	15	6
Publications	50	15	6
Maintenance of building, aquaria, taxes, insurance	311	14	2
Office expenses, printing, etc	128	2	4
Glass, chemicals, apparatus	157	15	1
Purchase of specimens	56	2	8

	£	s.	d.
Maintenance of boats, nets, gear, etc	253	3	5
Marine insurance	108	4	6
Coal and water for steamers	130	19	6
Interest	12	14	5
Applied toward purchase of steamer *Huxley*	228	13	10
Deficit from previous year	310	7	8
Total	3,134	5	9

It is estimated that the receipts from the aquarium and sales of specimens do not reimburse the station for the expense of maintenance of the tanks and cost of collection. The international investigations are carried on a budget (£6,000 per annum) independent of that of the station.

The Plymouth station for a season conducted elementary instruction for fishermen in conjunction with the local county council under Doctor Kyle's supervision, but this has been discontinued. At the time of the Easter recess a vacation course in marine biology, continuing for four or five weeks, is conducted at the station usually by some member of the biological staff at Cambridge or Oxford. The course consists of field and laboratory work, with daily lectures and demonstrations. A fee of £5 is charged for the full course and students provide their own instruments, the station furnishing laboratory facilities, reagents, and material. The income from this source is shared by the station and the instructors. Students are expected to have had elementary training, at least, before applying for admission to these courses. Often as many as twenty-five students attend the vacation courses.

The Plymouth station fulfills its function as a research institution (aside from economic investigations) by offering facilities for individual workers to carry on their own investigations. As an institution it attempts no coordinated programme of work outside of the somewhat immediate interests of the fisheries. Research tables are provided in the station to the number of fourteen, with room in the smaller laboratory rooms for three to five more on a pinch. Five of the tables in the main laboratory are utilized for the fisheries work. The tables are rented to qualified investigators at a charge of £40 a year, £25 per half year, £5 per month, or £1 10s. per week. Members of the association have first claim to become renters of the tables. Governors and founders have a right to the personal use of tables without charge, and on permanent foregoing of this privilege may nominate an eligible person to a table one month per year free of charge. Life members receive a reduction of one-fourth in charges, and to state-recognized authorities tables are free. Glassware for laboratory use, the ordinary reagents, material for investigation and the facilities for obtaining it are supplied to occupants of tables and a monthly allowance of 2 gallons of alcohol and a half pound

of absolute alcohol is made. Microscopical supplies and expensive reagents may be purchased at the laboratory. The station does not supply microscopes or other instruments. A list of the free equipment is furnished and a copy of the "Regulations for the working of the laboratory" is sent on application. Each investigator is allotted a part of the tank space in the main laboratory. The association does not permit naturalists to make zoological collections at the station, but provides these for sale at fixed prices. Price lists are sent on application. No charge is made for material collected by investigators for personal use, beyond that for containers and packing. A collection of named specimens available for reference and for use in identification of material is found in the station. All investigators are expected to furnish to the director, upon the completion of their work in the laboratory or within three months thereafter, a summary suitable for publication in the "Journal."

The station is open throughout the year and its facilities are available for all equipped investigators on application to the director. Seven days' notice is expected. The best season in the matter of collecting facilities is from March 15 to September 30. Pleasant lodgings at moderate prices and good hotels are to be found within a short distance of the station. American investigators find a cordial welcome at Plymouth, a mild climate, and much of interest and diversion in the vicinity.

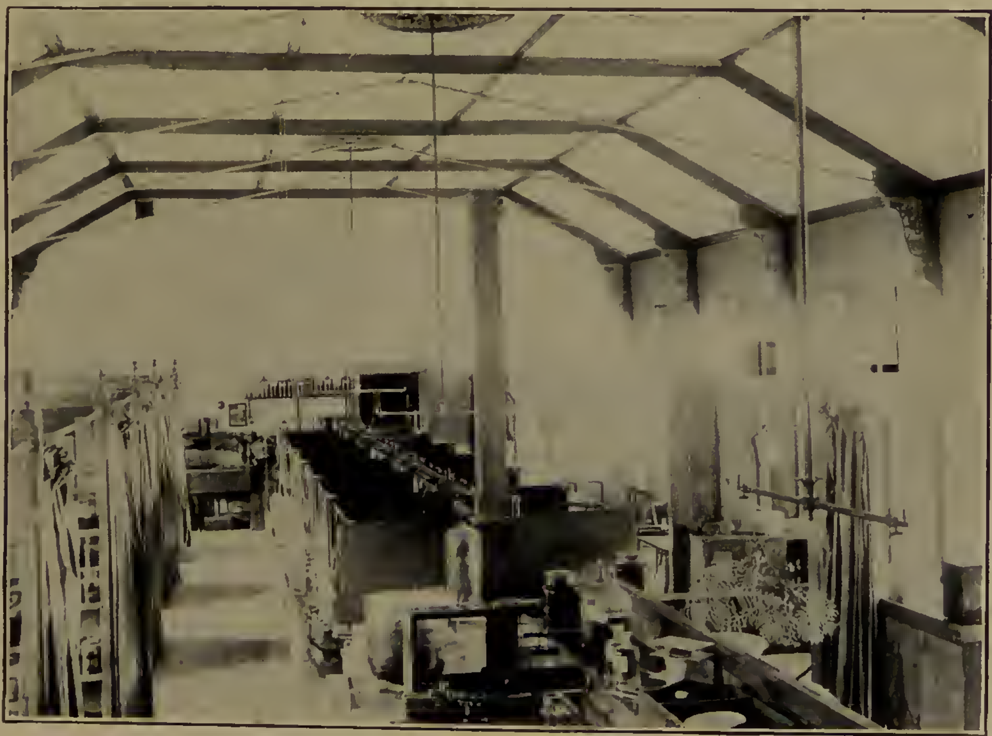
The Plymouth station occupies a commanding position adjacent to the citadel overlooking the sound, at the end of the famous promenade, "The Hoe," with its statue of Sir Francis Drake and the Eddystone light tower. It stands near the edge of a sloping rocky cliff at an elevation of 95 feet above sea level. Its grounds (240 by 265 feet), granted to the association by the war office, occupy the whole length of King Charles Curtain and have an area of about 63,600 square feet. A road lies between this plat of land and the sea, and private access to a small section of the seaboard is provided for by means of a tunnel 7 feet 6 inches high and 6 feet 6 inches wide, which leads from the area surrounding the cellars, beneath the road to the rocks below.

The building is placed 90 feet from the wall of the citadel, and is about 60 yards from high water mark. It is in the form of two blocks, which are each 34 feet 6 inches long by 42 feet wide and three stories high (40 feet), and a central connecting portion 70 feet long by 34 feet 6 inches wide and two stories high (30 feet). The east, south, and west fronts are built entirely of dressed limestone, which has been excavated on the spot; but on the north front the window and door dressings are of brick.

The roof of the central portion is peaked and covered with slate; that of the two blocks is flat and covered with lead.

A. GENERAL VIEW.

After photograph by Mr. Smith.



B. INTERIOR OF GENERAL RESEARCH LABORATORY.

After photograph by Mr. Smith.

MARINE BIOLOGICAL STATION AT PLYMOUTH.

Below the western block cellars have been excavated 14 feet deep, surrounded by an area 6 feet 6 inches wide on the north and 4 feet

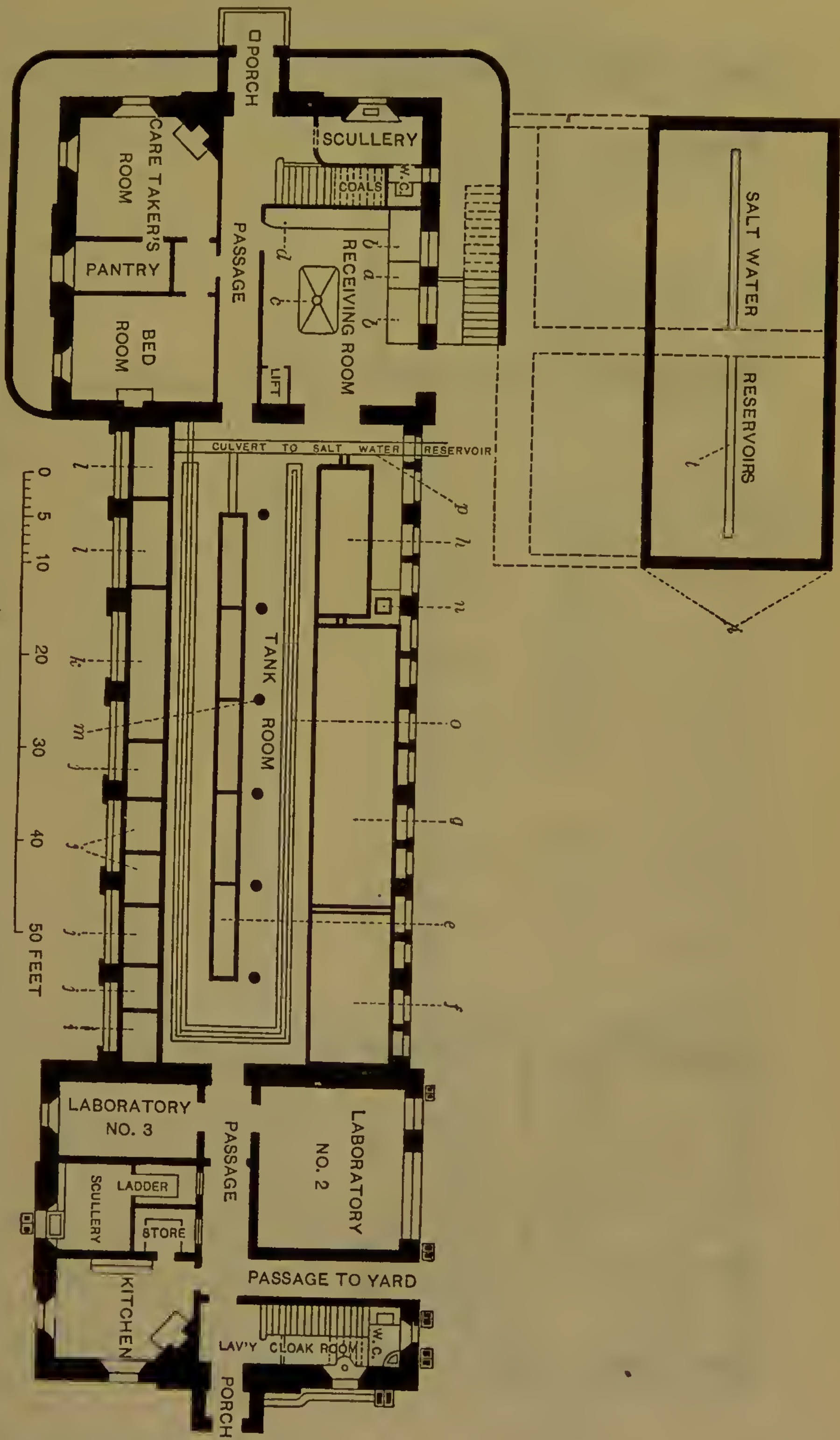


FIG. 13.—Ground plan of Plymouth station, after Heape (1887): *a*, Sink in receiving room; *bb*, tables; *c*, slate-topped table; *d*, shelves; *e*, five table tanks, each 9 feet 9 inches long, 2 feet 3 inches wide, 1 foot 9 inches deep; *f*, tank, 15 feet 6 inches long, 9 feet wide, 5 feet deep; *g*, tank, 30 feet 6 inches long, 9 feet wide, 5 feet deep: *h*, tank, 15 feet long, 5 feet wide, 5 feet deep; *j*, six tanks, each 5 feet long, 4 feet wide, 4 feet deep; *k*, tank, 15 feet long, 4 feet wide, 4 feet deep; *l*, two tanks, each 10 feet long, 4 feet wide, 4 feet deep; *m*, pillars to support Dennett's arching; *n*, manhole into circulating reservoirs along north side; *o*, trench covered with grating containing hot-water pipes; *p*, culvert conveying salt water from

wide on the west and south sides; further, the excavation has been extended between the cellars and the citadel wall to form two reser-

voirs (figs. 13, 15) for salt water, each 37 feet 6 inches long, 21 feet 6 inches wide, and 13 feet deep, and each capable of holding 50,000 gallons. The roof of a portion of each of the reservoirs is 6 feet higher than the remainder and is fitted with a gangway to enable a man to walk inside. These reservoirs are built of concrete and coated with a special asphalt; they are arched with brick and completely covered over.

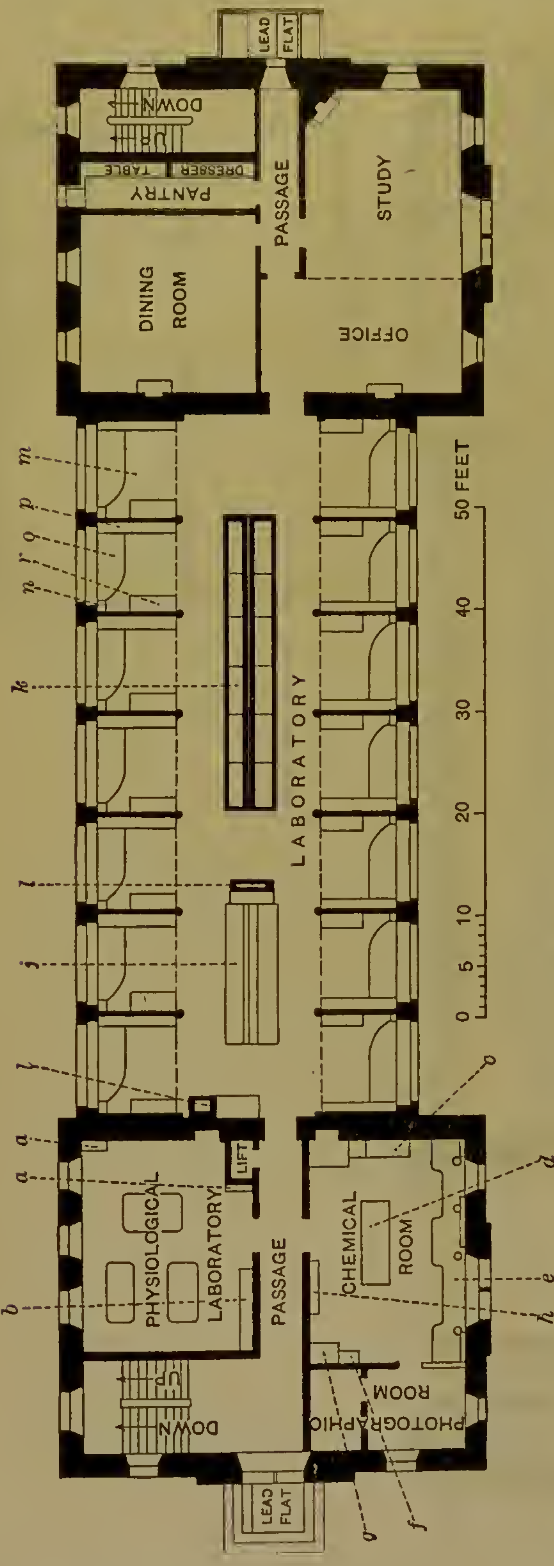


Fig. 14.—First-floor plan of Plymouth station, after Heape (1887): *aa*, Two sinks in physiological laboratory; *b*, cupboard with air-tight glass doors; *c*, sink in chemical laboratory; *d*, slate-topped table; *e*, bench; *f*, blowpipe table; *g*, stink cupboard; *h*, shelves; *j*, slate-topped table in main laboratory; *k*, twelve tanks, each 1 foot 6 inches wide, 2 feet 3 inches deep, 5 feet long; *ll*, two sinks; *m*, a "compartment;" *n*, sink; *o*, bench; *p*, shelves; *r*, table with drawers and cupboards.

The arrangement of rooms in the building is as follows:

Cellars.—The cellars (fig. 15) are 13 feet high, and consist of an engine room 20 by 16 feet; a boiler room 20 by 11 feet; an engineer's room 13 by 11 feet, a coal cellar, storeroom, and toilet. Access to the cellars is provided for by means of steps down into the area on the north side.

Ground floor, west block.—The rooms on the ground floor (fig. 13) are 12 feet high. The main entrance to the building is in the center of the west face of this block, and leads, on the one hand, by means of a straight passage 6 feet wide directly into the aquarium, and on the other, by means of a staircase 9 feet wide, to the first floor. On

the south side of the entrance are two rooms to serve as kitchen and bedroom for the caretaker of the building. These rooms are each 14

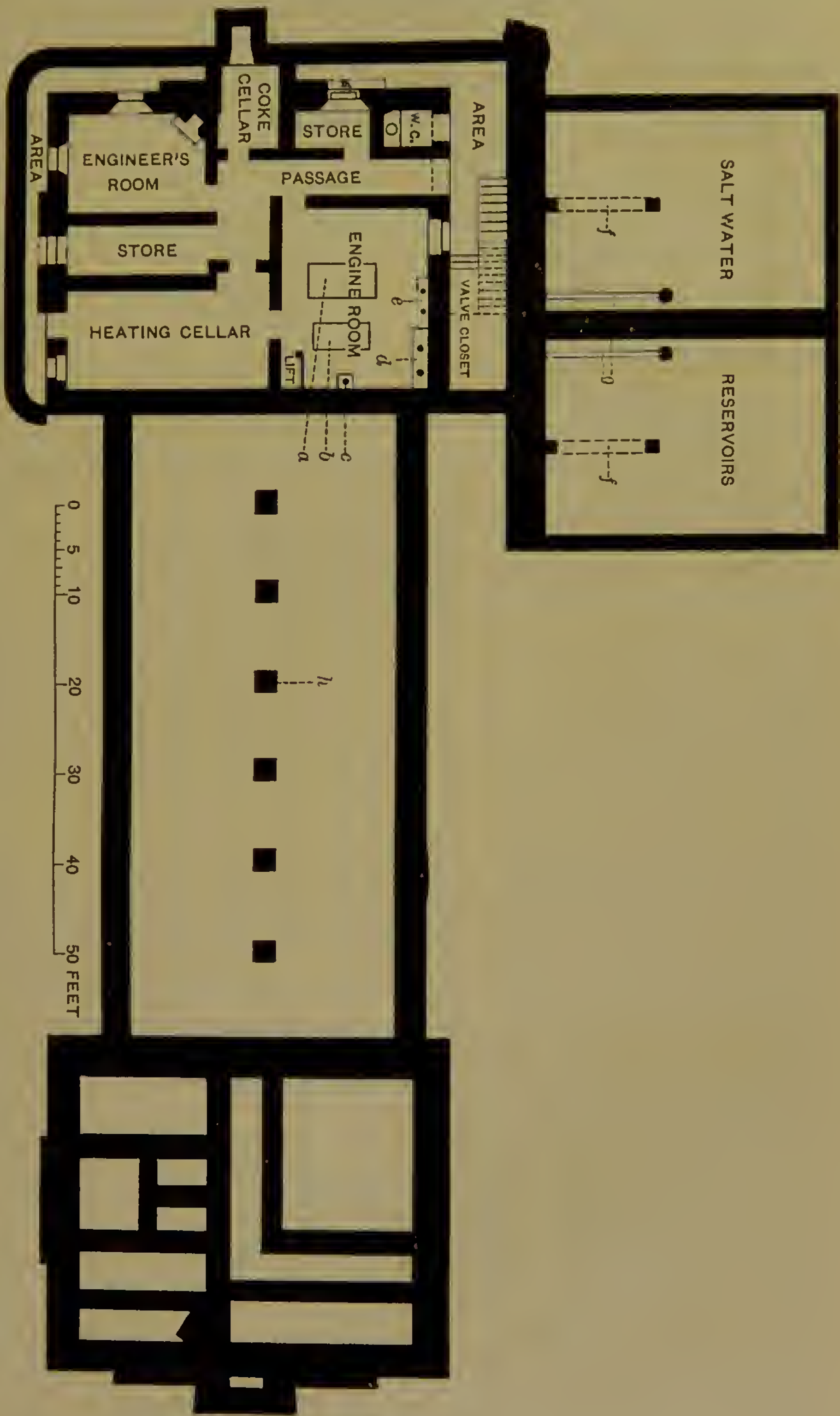


Fig. 15.—Plan of cellars and foundations, Plymouth station, after Heape (1887): *a*, Four-horsepower gas engine; *b*, 2-horsepower gas engine; *c*, compressed-air receiver; *d*, duplicate pumps to throw 7,500 gallons an hour; *e*, duplicate pumps to throw 2,000 gallons an hour; *f*, arching, in plan; *g*, drains; *h*, foundations for pillars to support Dennett's arching.

by 12 feet, and between them is a pantry 9 feet by 6 feet. On the north side of the entrance the scullery and offices for the caretaker,

the staircase leading to the first floor, and a "receiving room" 20.5 by 16 feet are placed.

Receiving room.—Materials for workers in the laboratory and to stock the aquarium are brought by the fishermen into the receiving room. This room is on the ground floor in the western block above the engine room, and communicates directly by means of doors with the yard outside and with the aquarium, and, by means of a lift, with the floors above it. Outside of the entrance in the area behind the building is a shallow open tank of asphalted wood and gravel bottom (3.5 by 18.5 by 1.7 feet) used as a filter bed and for temporary storage of unsorted material. The room is fitted with a large sink (*a*), with tables upon which the sorting of material and the dissection of large animals can be carried on (*b*, *b*, *c*)—one of these tables (*c*) is supplied with a slate top—and with sufficient shelves (*d*). A supply of fresh and salt water and a coil for heating water is placed over the sink.

Center.—The central part is occupied by the exhibition aquarium room, from the east end of which a door leads into the east block.

East block.—On the north side of this block is Laboratory II, 17.5 by 16 feet; on the south side, Laboratory III, 15 by 9 feet. Both are equipped with simple laboratory fittings. The remainder of this floor of the block is occupied by the kitchen and offices of the superintendent's residence. The main entrance to the residence is in the center of the east face of the block; it leads into a passage from which direct communication with the aquarium is provided. A staircase 7 feet wide leads to the first floor. A back door is placed on the north side.

Second story, west block.—The rooms on this floor (fig. 14) are 11 feet high. The staircase opens on to a landing above the entrance hall, and from this point a staircase communicates with the third floor, and a passage 6 feet wide leads into the main laboratory. On the north side of this passage is the physiological laboratory, 20.5 by 16 feet, now used largely as a collection and preparation room. There are two sinks in this room, each 3 by 1.5 feet; one of these is of glazed earthenware and is supplied with salt as well as fresh water; the other is of wood lined with lead (*a*, *a*). A large cupboard, 8 feet 8 inches long, 6 feet high, and 15 inches deep, with air-tight glass doors, is fitted against the south wall (*b*) and shelves on the east wall. Two substantial tables, 3 by 6 feet and 3 feet high, and one table, 4 by 6 feet and 3 feet 3 inches high, are also supplied; these tables are not fixtures, but can be moved about as desired. On the south side is the chemical laboratory, 14 by 22 feet. A bench runs along the windows 3 feet 3 inches above the floor and 3 feet wide. Four stoneware basins are let into the bench at intervals, and fresh water conducted to each. Shelves are placed against the window piers above

the bench and cupboards and drawers along its whole length beneath. A slate-topped table 1 by 8 feet and 3 feet 6 inches high is placed in the middle of the room (*d*), and contains four rows of drawers of different sizes, each row consisting of five drawers. A sink 6 feet long, with drying board, table, and shelves, occupies the east wall of the room (*c*); shelves are placed along the north wall (*h*), and a stink cupboard (*g*), and blow-pipe table (*f*) along the west wall. A small room 8 by 14 feet communicates with the chemical laboratory. These two laboratories are entered through doors which open into the passage. At the end of the passage a door leads into the center.

Center.—The main laboratory occupies the whole of the first floor of this portion of the building. It is provided with seven large windows on each side, which reach from a point 2 feet 6 inches from the floor to a height of 10 feet from the floor. The roof is a collar-beam roof with tie-rods leading down to the feet of the principals. It is 16 feet from the floor to the ceiling along the center of the room. The floor is specially constructed of Dennett's arching to insure freedom from vibrations. Along each side of the main laboratory are seven compartments (*m*) each 8 by 10 feet wide, formed of wooden partitions on either side, 7 feet high and by a curtain suspended from a rod behind. (See Pl. XXXII, *B*.) Each of these compartments is fitted along the window with a bench (*o*) 9 feet long, 4 feet 3 inches wide, and 2 feet 6 inches high, and an earthenware sink (*n*) 1 foot square and 8 inches deep. On the one side is placed a chest of drawers and cupboards (*r*) 4 feet 6 inches long, 3 feet high, and 1 foot 8 inches deep, and the whole of the other side is occupied with a set of shelves (*p*) conveniently arranged to hold small and large bottles. The sink is supplied with compressed air and fresh water; gas outlets are conveniently placed on the bench, and a gas bracket on the central pier of the window frame. Between these compartments on either side of the laboratory is a space 14 feet wide. The eastern portion of this space is occupied with the series of twelve small tanks. (Pl. XXXIII.) They occupy a space 4 feet 6 inches wide and about 30 feet long. In a line with these tanks is a slate topped table (*j*), 14 feet long and 5 feet 8 inches wide, along the center of which is a partition 2 feet high supporting a shelf. Water and gas taps are placed at intervals along the table. A large sink, 5 feet long and 2 feet wide, is placed at one end of this table, and another sink, supplied with drying board, hot-water coil, etc., is fixed along the western wall of the room (*l*, *l*). A cupboard 3 feet high is placed beside this latter sink and shelves above the cupboard.

East block.—The rooms on this floor are a dining room, pantry, and study for the superintendent, and an office from which a door leads directly into the main laboratory.

Third story, west block.—The rooms on this floor (fig. 16) are 10 feet high. The staircase and passage are same as on the second floor. On the north side of the passage is a lavatory, 8 by 16 feet, for the convenience of workers in the laboratory, and a private workroom, 12 by 16 feet, while the whole of the south side is occupied by the library (16 by 30.5 feet).

East block.—This floor is occupied by the quarters of the superintendent. A small staircase 2 feet wide leads from the third floor on to the flat roofs of each block.

The greater part of the building is heated by means of air, which is passed over pipes through which hot water circulates at a low pressure. A boiler is fixed in the cellars and pipes are carried from it into the receiving room, along the north and south walls of the laboratory, into the chemical and physiological laboratories, the library and the superintendent's office and living rooms. These pipes are cased in, fresh air is admitted within the casing through perforated bricks, and is distributed into the rooms through short,

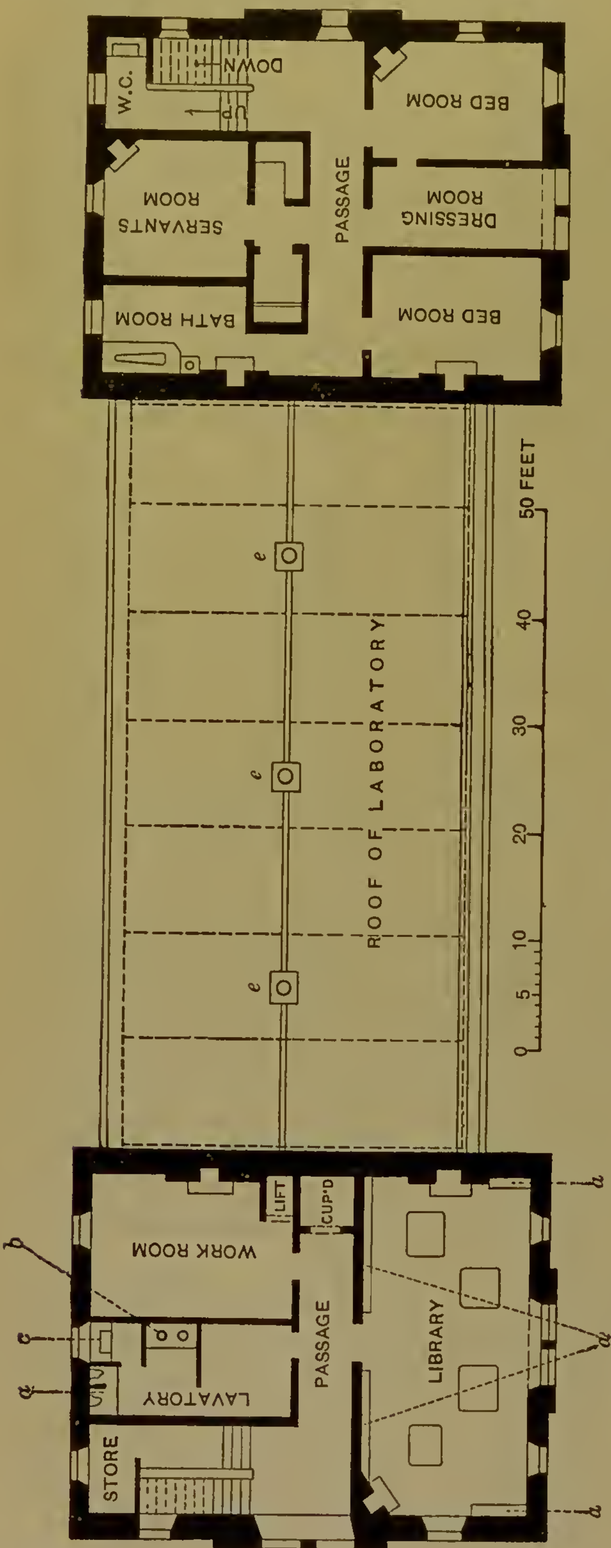
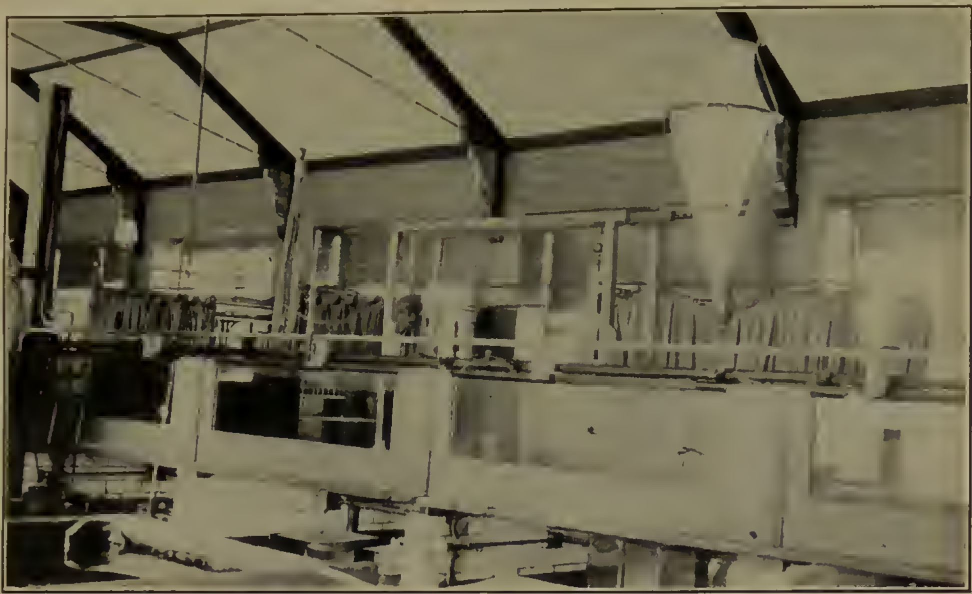


FIG. 16.—Second-floor plan, Plymouth station, after Heape (1887): *aaaa*, Shelves in library; *b*, wash hand basins in lavatory; *c*, water-closet; *d*, urinals; *eee*, revolving ventilators.



A. GENERAL VIEW IN RESEARCH LABORATORY.

B. SIDE VIEW OF AQUARIUM AND BASE.

AQUARIA AT PLYMOUTH.

vertical shafts placed against the wall at intervals. The top of each shaft is provided with a valve which can be regulated as desired and through it the warm air enters the room. The aquarium is warmed by means of hot-water pipes lying in a trench covered with iron grating along the passages between the three rows of tanks (fig. 15).

Ventilation is provided for by means of shafts in the walls dividing the central portion from the two ends blocks, into which the foul air from the room is conducted through grids. The up-draught in these shafts may be assisted by means of revolving ventilators (fig.16) placed in the roof.

The pumping plant at the Plymouth station consists of a 4-horse-power Otto (Crossley Brothers) gas engine, burning illuminating gas and a 2-inch Bon Accord cast-iron centrifugal pump with driving pulley 3½ by 2½ inches and 7½-inch fan. A hard-rubber pump, first installed, was discarded. The engine room is 86 feet above mean low tide and the sea pipe is 760 feet in length, of 4 inches enameled cast-iron, terminating 17 feet below low water of ordinary spring tide in a vertical iron screen raised 2 feet above the bottom. A smaller gas engine (2 horsepower) of the same type is used for the constant circulation of sea water in the building.

The 4-horsepower pump drives an air compressor which is used in connection with a Shones ejector at sea level to fill the reservoirs. Water is occasionally added to the reservoirs to make up for evaporation and loss. The reservoirs are used alternately a week at a time and are refilled once in six or eight months or oftener according to the condition of the water.

The piping, except for short sections of iron pipe adjacent to the pump, is of vulcanite throughout the building, with valves of brass near the pump and terminal cocks of hard rubber. The mains going to the aquarium are 3¾ inches (inside diameter), decreasing to 3½ and 2 inches, with terminals of ¾-inch and ⅛-inch terminal orifice, about 6 inches above water of aquarium.

The mains to the laboratory are of 2-inch pipe, with laterals of 1½ inches and terminals of glass tubing. The vulcanite piping is made up with sleeve couplings. No high-level reservoir is used, the water being forced directly into the tanks by the pump which is kept in continuous operation day and night.

The exhibition aquaria (fig. 13) are arranged on either side of the exhibition room (34½ by 70 feet). On the north wall are three large tanks; two of them (*f* and *g*, fig. 13) are 5 feet deep and 9 feet wide and 15½ and 30½ feet long, respectively, while the other (*h*) is 5 by 5 by 15 feet. The plate glass in these aquaria is in panes 4 feet 3 inches by 5 feet 10 inches and 1 inch thick. They are set in aquarium cement made of genuine white lead made into a stiff putty with powdered whiting to which a little Russian tallow is added to prevent hardening

too soon. The sides, back, and bottom of the aquaria are of 2 inches slate set up in red lead.

On the south wall of the room is a row of 9 tanks 4 feet wide and 4 feet deep, one (*k*) 15, two (*l*) 10, and six (*j*) 5 feet in length, with plate glass in panes 3 feet 4 inches by 5 feet 10 inches and 1 inch thick, with floor, back and sides of 1¾ inches slate.

Both series of tanks rest upon culverts of brick and concrete lined with asphalt, that upon the north side incloses a circulating reservoir 3 feet 6 inches deep and 7 feet wide, and that on the south side is 2 feet 6 inches wide and 3 feet 6 inches deep. The tanks above discharge through vertical standpipes with surface run-off into these reservoirs which in turn discharge into the main storage reservoirs through a concrete culvert.

In the center of the exhibition room is a row of five narrow table tanks 9 feet 9 inches long, 2 feet 3 inches wide, and 1 foot 9 inches deep, with tops but 4 feet above floor level. They have plate glass sides with panes 4 feet 3 inches by 1 foot 1 inch and ½ inch thick, and slate uprights and frames of 1⅞ inches slate, backs and floors of 1¼ inches, and partitions of 1½ and 1 inch.

The aquaria are all arranged with end-to-end circulation with overflow on partition walls or each may have its independent circulation.

In the research laboratory there is a series of twelve centrally located aquaria (Pl. XXXIII), similar in construction to the table aquaria in the exhibition room, each 5 feet long, 2 feet 3 inches wide, and 1 foot 6 inches deep with side panes of plate glass 4 feet by 1 foot and one-half inch thick set in slate frames with slate floor, partitions, and backs.

The Plymouth station has a full equipment for the chemical work in connection with salinity determinations and a Fox gas apparatus for analysis of gases in sea water. The laboratory has no equipment for bacteriological work or for special work in animal physiology.

There is an abundant equipment of glassware and the ordinary chemicals and reagents used in morphological work and paraffin ovens for embedding. Microscopes and microtomes are not furnished. Among the interesting apparatus at the Plymouth station is the stirring device invented by Dr. E. T. Browne (1898) for keeping medusæ alive in aquaria. It consists of a plunger made of a glass plate fastened obliquely upon a vertical glass rod, which is moved up and down in the aquarium automatically by means of a lever, at one end of which a bucket, located in the tank room, is alternately filled and emptied by a siphon, after the fashion of the Scott-Johnstone tip bucket.

A type of aerated aquarium for culture of small attached plankton-feeding organisms, such as hydroids, has also been devised by Pro-

fessor Browne (1907), as shown in figure 17. It consists of a tall aquarium jar aerated by compressed air, which enters through the tube *E* and escapes in the vertical tube *C*, which is one arm of a U tube *B*. The end of this tube is inserted through a cork in the bottom of a culture tube *A*, in which the animals are suspended. The ascending column of air bubbles in the one arm maintains a downward current through the culture tube, bringing to the organisms therein the plankton of the water for food. Animals in such tubes are free from sediment and thrive luxuriantly without connection with an outside system of water circulation.

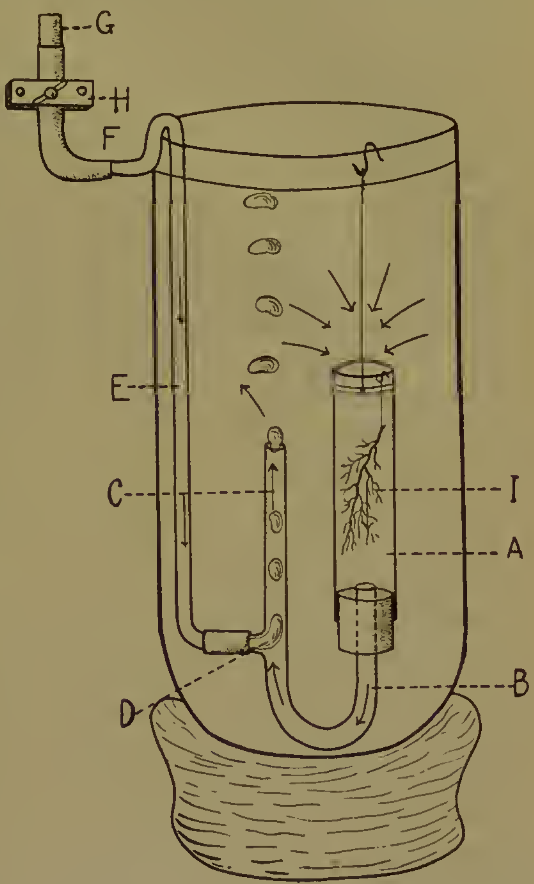


FIG. 17.—Dr. E. T. Browne's current table for growing hydroids. After Browne (1907). *A*, glass tube 9 by 23 cm.; *B*, *C*, *D*, *E*, glass tubing; *F*, rubber tubing; *G*, tube with compressed air; *H*, compressor.

There is no exhibition collection of the local fauna and flora, but a large collection of carefully identified types of the local fauna is available for use. The library is excellent, containing over 3,900 volumes, including many sets of biological journals and receiving, by purchase and exchange, 140 current serials pertaining to biological and fisheries investigations.

The marine equipment for field work is most excellent. In addition to the steam trawler *Huxley* (see Lowestoft station), which is engaged the most of the time on international work, the station possesses the *Oithona*, home port Plymouth, which is only occasionally engaged in the international investigations and is at other times at the service of the station for collecting cruises. She is a ketch-rigged iron steamer of 69.3 gross tonnage, with inclosed cabin amidships containing four berths. She has a length of 84 feet, beam of 16 feet, and draft of 8.5 feet, and has compound inverted engines of 20 horsepower. She carries a crew of four men, a steam winch with lifting power of 2,500 pounds located forward, and galvanized steel cables 120 fathoms in length and $4\frac{5}{8}$, $2\frac{5}{8}$, and $\frac{6}{7}$ inches in circumference, used in dredging, trawling, etc.; a hand sounding

machine with 150 fathoms of 4 mm. galvanized steel wire rope is used for sounding, hydrographic instruments, and lighter forms of plankton nets. This has since been replaced by 450 fathoms of a 2.2 mm. galvanized cable, breaking strain 400 pounds, made of four strands of eight wires each of No. 35 gauge, and the winch has been connected with the dredging drum.

In connection with the fisheries work, the Plymouth station has accumulated a rich and varied assortment of gear and tackle for all types of marine exploration, and is also fortunate in the services of collectors of long experience and extensive knowledge of local conditions and collecting grounds. Otter trawls of very efficient type, beam trawls, Petersen young-fish trawls, dredges, plankton nets of Hensen and Nansen type, the Garstang closing net, and the international hydrographic instruments afford a very complete outfit for biological collecting of bottom and pelagic life and for thoroughgoing hydrographic explorations. The station also possesses a sailboat, the *Anton Dohrn*, a centerboard yawl 5 feet 10 inches by 19 feet 8 inches, for use in short trips for local collecting.

The investigations carried on by the staff of the station are published in part in the "Journal of the Marine Biological Association," o. s. 1887–88, n. s. vols. 1–8, 1889–1908. The more formal reports of the international investigations appear in the parliamentary blue books, code Nos. 1312, 1313, 2612, 2670, 2966, 3033, 3165, and 3837. A full list of all published researches made at the station appears in volume 8 of the journal.

Some account of the inshore environmental conditions in Plymouth Sound and the adjacent channel at the 30-fathom line will be found in the several papers by Director Allen (1899, 1904). The sound, with the estuaries of the Hamoaze and the Cattewater, afford a great variety of rocky shores of limestone and slate, with limited stretches of sand, and all types of bottom from rocky to muddy, with occasional beds of *Zostera*, and depths up to 10 fathoms. The outer grounds, attaining depths of 30 to 35 fathoms at a distance of 9 miles, are varied in character and afford ideal conditions for dredging and trawling. The tidal amplitude is considerable, the mean being 15½ feet and the maximum at spring 18 feet, affording a considerable range of shore collecting. The mean surface temperature is about 12° and the seasonal amplitude is from 7° to 8° C. The mean salinity in the channel is about 35.3, nearly that of normal Atlantic water. The location of the station, near two estuaries, receiving considerable fresh water and the sewage and industrial wastes of Plymouth and Portsmouth, necessitates care in the pumping of the water supply of the station. By pumping at highest tides and employing large storage tanks and a closed system of circulation, in which the water is used for a period of about six to eight months, the station is able to secure sea water

satisfactory for ordinary work and to maintain even fairly delicate organisms for a time in its aquaria. The fact that Plymouth and Brixham are important centers for the fisheries of the channel adds greatly to the resources of the station.

The published accounts of the local distribution and breeding seasons of the fauna of the waters adjacent to the Plymouth station exceed in completeness those available at any other European station. The account of the invertebrate fauna, compiled under the editorship of Doctor Allen (1904) from the records of the laboratory and various specialists who have worked at Plymouth, is of great service to naturalists intending to work at the station in giving a conspectus of the material available in that locality. The papers of Heape (1889) and Johnson (1890) give floristic lists of the marine algæ. Records of the plankton appear in the "Bulletin" of the central bureau at Copenhagen.

The fauna as a whole shows a predominantly southern (Lusitanian) facies, intermingled with a large element of northern fauna. With the entrance of Atlantic water into the channel a considerable increase ensues in its pelagic life, resulting in part at least from the addition of neritic components. The plankton at Plymouth is thus but partially oceanic in character. Some idea of the relative richness of the fauna at Plymouth may be gained from the fact that the lists contain 36 species of Echinodermata and 28 Zoantharia.

The Plymouth station offers to the naturalist a charming environment and in the main excellent laboratory and library facilities. There are also exceptional opportunities (in connection with Lowestoft) to inspect hydrographic and fisheries investigations of the highest efficiency, applied with a broad comprehension of the whole problem of the production of the sea, and a direction toward the solution of specific problems of the commercial fisheries rarely attained in fisheries work.

Literature: Allen et al. (1904), Heape (1887), Anon. (1884, 1884*a*), Browne (1896, 1907), Hartlaub (1902), Johnson (1890), Dean (1894), Sand (1897), and administrative reports and other papers in the Journal of the Marine Biological Association.

INTERNATIONAL FISHERIES INVESTIGATION FOR GREAT BRITAIN.

Board of agriculture and fisheries, Delahay street, London, S. W., England.

Members: Mr. W. E. Archer, assistant secretary board of agriculture, London; Prof. D'Arcy W. Thompson, Dundee; Mr. R. H. Rew, assistant secretary board of agriculture, London; Dr. R. H. Mill, director British weather bureau; Prof. W. Garstang, Leeds; Dr. A. T. Masterman, inspector of fisheries, London; Dr. E. W. L. Holt, scientific adviser, department of agriculture for Ireland; Dr. T. W. Fulton, Scottish fishery board, Aberdeen.

English branch:

Director, Dr. E. J. Allen, the Laboratory, Citadel Hill, Plymouth, England. Generally at Lowestoft.

The Lowestoft fisheries laboratory, Marina, Lowestoft, England:
  Director, Dr. E. J. Allen.
  Assistant director, Mr. J. O. Borley.
  Assistant naturalist, Dr. W. Wallace, for fishes.
  Assistant naturalist, Mr. R. A. Todd, for invertebrates.
  Statistical assistant, Miss R. M. Lee.
  Employees, one fisheries assistant, three clerical assistants, bookkeeper, and laboratory assistant.
  Telegraph address: Laboratory, Lowestoft.
International staff at Plymouth:
  Hydrographer, Mr. D. J. Matthews.
  Assistant naturalist, Mr. A. J. Mason-Jones.

The establishment of the International Commission for the Investigation of the Sea in 1902 in which Great Britain took a part resulted in the biological station at Plymouth being asked to take charge of the investigations in the southern British area in the scheme adopted at the general conference of the European powers, meeting at Christiania in 1901. The field of operations for fisheries investigations of the English bureau includes the North Sea west of 3° east and south of Berwick on the Tweed. Work has, however, been done practically all over the North Sea south of 56° north, with a few scattered stations north of that.

To facilitate the fisheries work in the North Sea a temporary laboratory was opened on the east coast in 1902 at Lowestoft, in hired quarters in the center of the North Sea commercial fisheries, and Dr. W. Garstang was placed in charge as assistant director. Upon his departure to Leeds University in 1907 Dr. E. J. Allen, of Plymouth, assumed charge in person of the work at Lowestoft.

The work is directed throughout toward the immediate solution of scientific problems arising in connection with the practical fisheries. At the close of 1908 the *Huxley* had made 105 cruises and 564 hauls of the otter trawl, 801 with the beam trawl, and 1,248 with other gear in exploration of fishing grounds. More than 550,000 fish had been measured in connection with the determination of age and growth and also 19,000 age determinations had been made by the examination of annual increment rings in the otoliths, scales or skeletal structures. The age determinations are used in the investigation of the distribution of age groups, the relation of size to age, the rate of growth on various grounds at different ages and in the two sexes, the proportions of the sexes at successive ages, and age at first maturity. A total of 14,500 marked fish had been released with a view to determining their migrations and movements, and experiments had been carried on in transplantation to less crowded areas. Marked cocoanuts and Bidder drift bottles devised for the study of bottom currents have been distributed at sea and the returns collected for the purpose of tracing ocean currents on fishing grounds.

The bottom fauna is studied with reference to its distribution and utilization as food by fishes with and without commercial value. Over 12,000 food determinations have been made. The bottom deposits are also subjected to physical and chemical analyses with a view to mapping the physical conditions on fishing grounds.

In addition to the biological investigations of the fisheries, extensive and thorough statistics of the commercial fisheries are collected and reduced by computation to show the average catch per haul of the standard trawl per month on the various banks, to check against the experimental trawling of the *Huxley*, and the study of the distribution of the age classes, with a view to tracing the fluctuations in the fish population and, if possible, detecting their causes.

Hydrographic and plankton work is also carried on in a series of quarterly cruises of the *Huxley* to selected stations. This work is supplemented by the examination of water samples, and in some cases plankton also, collected at frequent intervals at light-ships and by channel steamships and trans-Atlantic lines for the purpose of tracing the movement of oceanic waters and their relation to the harvest of the seas in British waters.

The hydrographic and plankton investigations are carried on at Plymouth, and the field of operations for this work is the English Channel, extended by cruises into the Bay of Biscay and Bristol Channel.

The station at Lowestoft is located on the Marina, a short distance north of the fisherman's wharf, in half of a dwelling house in which rooms have been fitted with laboratory furniture. No salt-water supply and aquaria have been introduced. Here are found the office of the director, a small working library, very extensive collections of the bottom fauna of the North Sea largely carefully determined, a fisheries laboratory, a zoological laboratory, a laboratory for the study of bottom deposits with physical and chemical outfit, and a Schönes levigating apparatus as modified by Borley for the sorting of bottom deposits by sedimentation, and a statistical office, where the records of the commercial trawlers are worked up.

The laboratory at Lowestoft makes no provision for instruction of any kind and has but limited facilities for research beyond the immediate needs of the staff, and no regular provision is made here for independent investigations as at Plymouth. The constant work of the *Huxley* and the extensive collections at the station afford exceptional access to the fauna of the North Sea, while the location of the station in a great fishing center brings within reach of the biologist a wide range of material. The Lowestoft station is also of prime interest to visiting biologists as one of the best illustrations of the intensive application of scientific methods to the study of fishing problems under scientific control to be found anywhere.

The *Huxley* is a ketch-rigged steel steamer with raised forecastle and quarter-deck carried forward to the foreside of the trawl winch, built especially for commercial steam trawling in the North Sea. The vessel is 115.7 feet long, 21.1 feet beam, with a depth amidships of 11.2 feet, and a gross tonnage of 206 tons (net 44). Her engines are triple expansion of 450 indicated horsepower, and the boat has a speed of 10 knots an hour. She carries four officers and a crew of eight men and has cabins and laboratory space for three naturalists. The laboratory is forward of the foremast in a deck house 10 feet 3 inches wide by 10 feet long, containing fish-measuring table and two swing laboratory tables. Trawling is done with steam winch of 12 horsepower and 200 fathoms of galvanized steel dredging cable 20 mm. in diameter. The boat is equipped with commercial otter trawl, with 90 feet head-line, and beam trawl with 44 feet beam, shrimp trawl, Agassiz trawl, Todd's crustacean trawl, dredges, tow nets, Garstang closing net, Hensen vertical nets, Petersen young-fish trawl, and the hydrographic instruments of the international commission, including Richter thermometers and Pettersson-Nansen and Ekman water bottles.

SUTTON BROAD FRESH-WATER LABORATORY, CATFIELD, GREAT YARMOUTH, ENGLAND.

Directors, Mr. Eustace Gurney, Sprowston Hall, Norwich; Mr. Robert Gurney, Ingham Old Hall, Stalham.

Address correspondence regarding the station to the latter at Sutton Broad Labora tory, Catfield.

Telegraph address: Catfield, Great Yarmouth.

Station, Stalham, Midland and Great Northern Railway.

The Norfolk Broads district on the eastern coast of England is one of unique biological interest. It is a flat marshy plain of some 5,000 acres traversed by about 200 miles of navigable rivers which often have lake-like expansions in their courses or in their adjacent, often interconnecting laterals. The southerly drift of sand and shingle along the eastern coast of Norfolk has since Roman times gradually closed the mouth of the great estuary, stopped the scour of the tide, and led to a gradual silting up of the channels. The reclamation of the adjacent marsh lands was begun by embankments as early as the twelfth century, and is now maintained by wind and steam pumps which throw back the flood water into the channels from the fields, many of which lie below flood-water level.

The broads fall into three main groups differing strikingly in their physical conditions and characterized by diverse conditions of vegetation and animal life. In the first group are broads of the Thurne River which are characterized by the high salinity of their waters, a flora consisting of the Characeæ and *Potamogeton pectinatum* and a

fauna including brackish-water species of *Neomysis*, *Gammarus*, and *Cordylophora*. The second group are the broads of the river Ant, shallow weedy expanses with a rich fauna of littoral species, but no purely pelagic species of Entomostraca. The whole area of these broads is filled with vegetation. The third group of broads are those of the river Bure, with well-defined shores, deep water, little or no vegetation, and a rich plankton of diatoms and Crustacea. They are in their biological and physical conditions typical lakes. The brackish-water fauna is found to some extent in some of these waters.

The degree to which the marine fauna invades the broads depends on several factors of season, tide, and storm. Prolonged northwest wind will carry Ctenophores and marine Copepoda to Sutton Broad, 25 miles from the sea. The daily tidal oscillation affects wide areas of the broads in an exceedingly complicated manner, reaching within a few miles of the station, while the chemical tide, traced in daily changes in salinity, ascends the stream but 12 miles. Salinity beyond the limits of the chemical tide is spread by diffusion and from the soil and in certain broads from local salt springs.

Sutton Broad was until recent times a sheet of open water of about 100 acres, but is now overgrown by weeds and aquatic vegetation, so that there is scarcely any open water except in channels which are kept free for navigation. The greater part of the vegetation consists of reeds (*Arundo*), reed mace (*Typha*), and bullrushes (*Scirpus*), whose matted roots form a floating platform strong enough to bear the weight of a man in places. There is much submerged vegetation in the semiopen water. The shores are low, ill-defined, and marshy, and the water level fluctuates with wind, rain, and to some extent at times in sympathy with the tides at Yarmouth. The extreme range in level is 19 inches. The greatest depth of water is 6 feet.

The Sutton Broad fresh-water laboratory was opened in 1901 in a building erected by Mr. Eustace Gurney on Longmoor or Gravel Point near Sutton Broad on the river Ant, a tributary of the Bure, opening to the sea at Yarmouth. The station is a private institution, built and equipped by private funds. Its directors are Oxford men who have interested themselves in the study of biological conditions in the Norfolk Broad district. From 1903 to 1907 Mr. F. Balfour Browne was director, and since that time Mr. R. Gurney has taken the duties of the office. In 1907 Mr. C. H. Martin was the naturalist of the station, but at present the station is without a naturalist. The station has no relation to educational institutions or the fisheries and gives no instruction. It is devoted entirely to the purposes of research. Qualified investigators are admitted to the privileges of the laboratory. Investigators should bring their own

microscopes. Living quarters can be had at the station without charge upon application to the director.

The lines of investigation followed at the laboratory in the past have been faunistic and developmental, dealing with distribution and life histories of aquatic insects, rotifers, crustaceans, and hydrachnids and with the botany and binomics of the area of investigation. Chemical and tidal investigations have also been carried on for some time, and a botanical survey is projected. The results of the work of local character have been published mainly in the "Transactions of the Norfolk and Norwich Natural History Society."

The station is located about 1 mile by water from the railway stations at Stalham and Catfield, both on the Midland and Great Northern Railway, and 15 miles by carriage from Yarmouth. It is a small brick cottage with thatch roof, about 100 yards from the water's edge. It contains a general laboratory room with table space for four to five workers and bedrooms above for the same number. The laboratory has no circulating system, but is supplied with glass aquaria. There are microtomes and a good supply of the ordinary chemicals and glassware used in morphological work, but no provision for bacteriological, physiological, or hydrographical investigation. The station has at its disposal several small boats, a 16-foot 4-horsepower motor boat and a wherry, the *Cyclops*, a trading vessel of 22 tons converted into a floating laboratory and residence for field work at a distance from the station.

The Sutton Broad laboratory, the only English fresh-water station, is in an ideal situation for the investigation of the fresh and brackish water fauna and flora and for an attack upon those fundamental biological problems of adaptation of organisms to different chemical media.

Literature: Gurney (1904, 1908), Nicholson (1895).

DOVE MARINE LABORATORY, CULLERCOATS, NEAR NEWCASTLE, NORTHUMBERLAND, ENGLAND.

Director, Dr. Alexander Meek, Cullercoats, England.
In addition, an attendant, clerk, and a boy.

This biological station owes its origin to the efforts of Prof. Alexander Meek, of Armstrong College, Durham University, Newcastle. In 1897 he opened a small laboratory in temporary quarters at Cullercoats Bay, 2 miles north of the mouth of the Tyne and 10 miles from Newcastle in connection with the work of the Northumberland sea-fisheries committee. The temporary laboratory was burned in 1904. This was replaced by a fine new building (Pl. XXXIV, *A*), upon the old site, completed and opened for use in the summer of 1908.

A. GENERAL VIEW, CULLERCOATS, "COBBLE" IN FOREGROUND.

Photograph by Prof. A. Meek.

B. INTERIOR OF RESEARCH AQUARIUM ROOM, SHOWING BANKS OF CEMENT TANKS.

Photograph by Prof. A. Meek.

DOVE MARINE LABORATORY AT CULLERCOATS.

The present building, with its fittings, costing about £5,000, was erected A. D. 1908 by Wilfred H. Huddleston, M. A. and F. R. S., for the furtherance of marine biology, and as a memorial of his ancestress, Eleanor Dove.

The building stands upon a shelf at the foot of the cliff that encircles the diminutive harbor of Cullercoats. Its foundations are protected by a concrete wall which rises from tide level to a height of 10 feet. The building faces the east. It is rectangular in form with outside dimensions of 33 by 70 feet and its long axis running north and south. It is built of pressed brick with stone trimmings and is three stories in height. It is entered by a bridge from the cliff to its uppermost story. Upon this floor are found only the retiring rooms and lavatories, surrounded by a promenade and parapet, which incloses in one corner

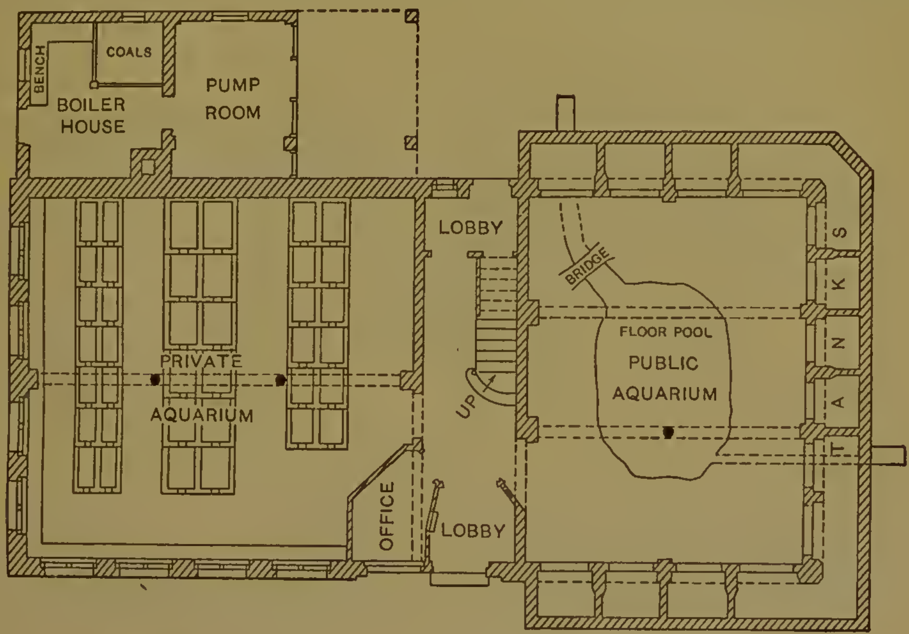


FIG. 18.—Ground floor, Dove marine laboratory. Cullercoats.

an open cement tank 15 by 8 by 3 feet 7 inches, which supplies the salt water to the laboratories of the floor below.

The middle or main floor contains a lecture room (19 by 23 feet) with blackboard and lantern screen, and table room for a small class of elementary students; the private laboratory (15 by 10½ feet) of the director, a dark room (4 by 7 feet), a small private laboratory (8 by 7 feet), a reagent room (4.7 by 14.7 feet), a collection room (13.6 by 14.7 feet), a library (13.6 by 14.7 feet), and a general laboratory at the southeast corner (14.7 by 32.6 feet) with six cubicals (6 by 6.8 feet) separated by low partitions.

The rooms are supplied with gas, electric light, hot and cold water, and salt water. Each laboratory is provided with a teak-wood desk and porcelain sink-aquarium. Paraffin baths and microtome are found upon a centrally located table in the general laboratory.

The ground floor (fig. 18) contains a small office and lobby and two large aquarium rooms. The public aquarium (admission, 3 pence) occupies a large room (40.8 by 29 feet) at the north end. It has eleven ferroconcrete (Henne bique system) aquaria with plate glass fronts. The aquaria occupy three sides of the room, while in the center of the floor is found a pool 19 inches in depth (11 by 16 feet) with a central fountain. The aquaria are lighted through a sloping glass roof which projects from the building. A narrow iron gallery projecting into the aquarium room above the level of the glazed openings affords access to the aquaria for care and cleaning. The openings above the glazings are closed by curtains so that the room is lighted solely through the aquaria. The bank of aquaria is 5.4 feet in height and has a uniform width (from front to rear wall) of 4 feet. The glazed

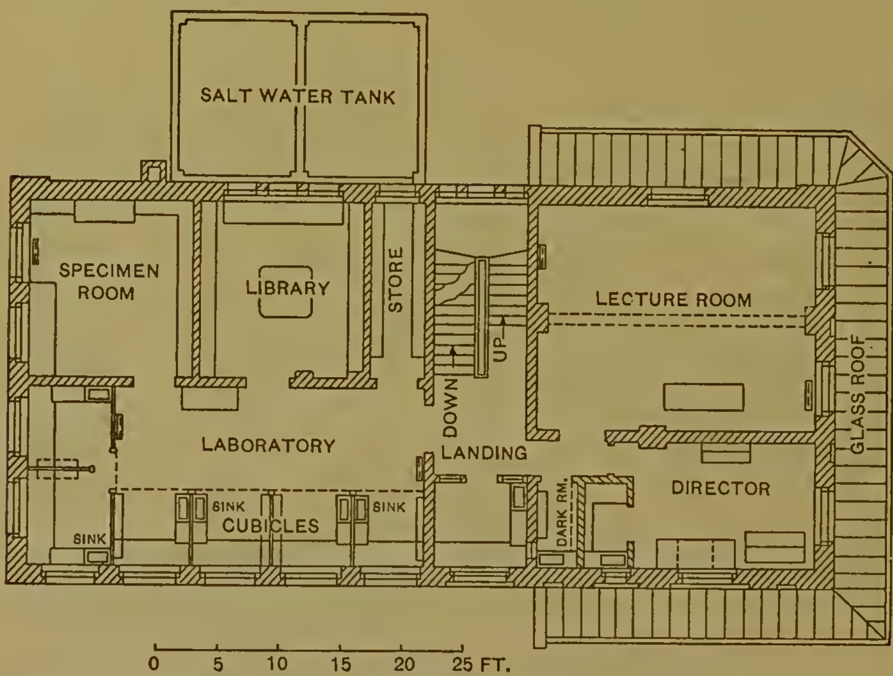


FIG. 19.—Main floor, Dove marine laboratory. Cullercoats. From Meek (1909).

openings vary in size from 3.10 by 5 to 4.10 by 5 feet. Nine of the aquaria have but a single glazed front but the corner aquaria are larger, having two and three openings, respectively. The floor below the tanks is depressed in a large trough, which is continuous under all the aquaria, and forms a long channel 4 by 86 feet and 2 feet in depth in its center. This channel receives the discharge from the tanks and serves as a fish tank for large fish.

The water supply is pumped by an electric motor and pump, housed beneath the double ferrocement tanks 14 by 21 by 12.6 feet, holding about 15,000 gallons, placed at the level of the second floor at the rear of the building. The sea pipe is of 4-inch black iron terminating in a rose about 270 feet from the building, on the sandy beach near low-tide mark. The distributing system is of galvanized

iron piping, galvanized after fitting, with gun-metal cocks. A tank upon the uppermost floor supplies the laboratories while the aquarium rooms are fed wholly by the large tanks. Each aquarium tank has its own independent feed (by overhead jet) and discharge, or all aquaria can be thrown into a common system of circulation. Each has its independent flush pipe set in its floor, and has an overflow outlet set in the dividing partition shielded upon either side by silk or wire screens and discharged into the trough-aquarium beneath.

The worker's aquarium room (Pl. XXXIV, *B*) (30 by 32.6 feet) is in the southern end of the building. It contains 38 separate aquaria with overhead water supply. The aquaria are arranged in three rows of 7, 6, and 6 double tanks, respectively. They are in banks stepped down in 3-inch intervals from one end to the other, so that the water may pass through from one aquarium to the next in the bank, if desired. Each aquarium may also be operated independently with its own supply and discharge, if desired. The discharge passes into an open trough in the cement floor.

These aquaria were built in situ of ferrocement. Their walls are 4 inches thick and their inside dimensions are:

Length.	Width.	Depth.
3 feet $1\frac{3}{7}$ inches.	1 foot 5 inches.	9 inches.
3 feet $8\frac{1}{3}$ inches.	2 feet 5 inches.	12 inches.
3 feet 1 inch.	1 foot 11 inches.	9 inches.

Each aquarium has its sides slotted obliquely at the end next the outlet plug for a silk or wire screen to prevent the escape of larvæ. Around two sides of this room runs a cement shelf 15 inches wide, sloping slightly toward the wall and provided with a small gutter at the rear, which discharges into a floor gutter connected with the waste pipe. A salt-water supply is carried along this shelf, which is used for small detached aquaria. In front of one window is an aquarium, arranged for photographing living animals, so placed that an opaque background or transmitted light may be used. The water supply for this room passes through an elevated wooden tank where it operates a Johnstone-Scott tip bucket, which provides for an intermittent plunger similar to that used in the Port Erin fish hatchery in the Danevig hatching boxes.

A boiler room, for the heating apparatus, and shop and pump room, occupy a space 14 by 35 feet at the rear of the building.

The staff of the Dove marine laboratory consists of the director, Prof. Alexander Meek, an attendant, clerk, and boy. A resident naturalist will be added to the staff as soon as funds can be provided for the purpose. The laboratory is a department of Armstrong College, Durham University at Newcastle, and is administered by

the director, who reports to a marine laboratory committee, consisting of the principal of the college, two members of its faculty, two representatives of the Northumberland sea-fisheries committee (composed of members representing the British Government and the county council for Northumberland), and one representative of the county council.

Five of its research tables are supported by annual contributions of £10 from the University of Durham, Armstrong College, the Natural History Society of Newcastle, and the Northumberland Coast Club. Its income is derived from an annual grant from the county council of £200, interest upon a building fund, private subscribers, and admissions to the aquarium. It pays an annual rental of 3 per cent upon the cost of the building to its present owner.

Special investigations have been carried on since 1896 at the Cullercoats station at the expense of the Northumberland sea-fisheries committee, which, however, contributes nothing directly to the support of the laboratory. These investigations have been a study of the food and parasites of fish, the migrations, breeding habits and biology of crabs and lobsters, and of certain food fishes, the statistical study of the distribution of food fishes, especially of young fish, within the 3-mile zone in which trawling is prohibited, hatching experiments, the study of bottom deposits on fishing grounds, and faunistic studies on the marine Crustacea and Mollusca of Northumberland. The results of these investigations have been published annually in a "Report on the Scientific Investigations, Northumberland Sea-Fisheries Committee."

No classes for the formal instruction of fishermen have been held at this station, but conferences for the discussion of fishing problems are held by the director from time to time in fishing villages along the coast. No classes for elementary instruction or teacher's vacation classes have been held, but it is proposed to develop these lines of instruction in the near future.

The station possesses a small working library of literature pertaining to the local fauna, its original library being lost in the fire of 1904. Its library facilities are supplemented by those of Armstrong College and the Hancock Museum in Newcastle.

The field equipment of the station consists of the usual outfit of dredges, trawls, and tow nets. The station has one row boat, but fishing boats, the unique Cullercoats "cobles" (see Pl. XXXIV, *A*), specially constructed for beaching, may be readily hired, and the fishing fleet at North Shields affords other boats and steam trawlers for hire for special investigations. There is no equipment for hydrographic work. A motor boat, a gift to the station, is under construction; dimensions, length 50 feet, beam 11 feet, with 30 horse-power Gardner motor, built after special designs by Mr. Alexander, lecturer on naval architecture, Armstrong College.

The station is open throughout the year to investigators and is most frequented by local students during the summer months, July to September. Qualified students and investigators are admitted upon application to the director. A fee of a guinea a month is charged for the use of a laboratory table. American students are welcome and every available facility will be placed at the disposal of American investigators.

The vicinity of Cullercoats has been made famous as a collecting ground by the work of such naturalists as Alder and Hancock, who found not a few of the nudibranchs of their great monograph on the reefs at the mouth of the little harbor. The shores in the vicinity of the laboratory are of carboniferous shales and Permian sandstones, and bear the fauna and flora characteristic of these less stable rocks. There are numerous tide pools accessible on the reefs exposed at low tide. There are some *Laminaria* or *Fucus* beds in the vicinity and a coating of smaller algæ affords a hiding place for a considerable variety of mollusks and crustaceans. The sandy and pebbly beaches have an abundant burrowing fauna of worms and lamellibranchs. There are also mud flats accessible near the mouth of the Tyne. The bottom immediately offshore is quite varied in character and affords an abundant and diversified fauna for dredging. Cullercoats is the center of a considerable fishing industry. This and the adjacent extensive fish market at North Shields, supplied by the steam trawlers, make the rich fish fauna of the North Sea accessible to workers at this station.

The tidal amplitude at spring is about 10 feet at Cullercoats, and the average density about 1.026. The water supply at the station appears to be free from any considerable contamination by local sewage or by that from the cities on the Tyne.

No extensive summary of the marine fauna and flora of this region has been published, but many faunistic papers will be found in the "Transactions" of the Natural History Society of Northumberland, Newcastle, and Tyne, and an extensive collection in the Hancock Museum at Newcastle.

This station is well fitted for biological investigators in connection with the commercial fisheries and affords excellent provision for experimental or developmental studies where extensive equipment for the observation and rearing of living animals is a desideratum.

Cullercoats is easily reached from Newcastle by electric trains which run every fifteen minutes during the day. The fishing village has in recent years become a seaside resort, with an abundant supply of hotels and pensions conveniently located with reference to the laboratory, where accommodations can be secured at moderate charges.

Literature: Meek (1909).

LIVERPOOL MARINE BIOLOGY COMMITTEE.

Honorary president, Prof. W. A. Herdman, University of Liverpool.
Honorary secretary and treasurer, Mr. Edward Thompson, 53 Croxteth road, Liverpool.

This committee was organized in March, 1885, at a public gathering of local naturalists from Liverpool, Manchester, and neighboring cities, summoned by Prof. W. A. Herdman to meet at the University College, Liverpool, for this purpose. The objects of this committee were stated as follows: "To investigate the marine fauna and flora (and any related subject such as submarine geology and the physical condition of the water) of Liverpool Bay and the neighboring parts of the Irish Sea, and, if practicable, to establish and maintain a biological station on some convenient part of the coast." This committee consists of ten to twelve members, holding office for life or till resignation, with power to fill vacancies, and meeting at least once a year. An executive committee, consisting of the honorary director, who is also chairman, and the honorary treasurer, conducts the affairs of the committee ad interim. The committee defrays the expenses of the investigators and of the publication of their results, and for this purpose receives subscriptions and donations and grants from scientific funds. Professor Herdman has been the honorary chairman and director from the beginning and was ably seconded in the management of the committee's affairs for many years by Mr. Isaac Cooke Thompson, a Liverpool merchant, and at the same time an amateur naturalist of scientific tastes and training widely known for his extensive researches on the Copepoda. Mr. Thompson served as honorary secretary and treasurer for this committee from its organization in 1885 till his death eighteen years later. The simple organization and centralized administration of this committee stand in strong contrast to the diffuse organization of the committee controlling the Millport station. This phase of the organization has been one of the grounds for the continuous policy and economical administration which has characterized the stations established and maintained by this committee. The annual reports of this committee (the twenty-second appearing in 1908) contain the administrative reports of the chairman and treasurer and are published regularly in the "Proceedings of the Liverpool Biological Society." The committee also publishes the "Fauna and Flora of Liverpool Bay," Volumes I to V, and a series of illustrated "Memoirs" dealing with selected marine types, eighteen numbers having appeared up to 1909.

THE PUFFIN ISLAND STATION.

Directors: Prof. W. A. Herdman (1887–1892), Dr. P. J. White (1892–1904).

The preliminary investigations of the Liverpool committee in 1885–1887 demonstrated the necessity for a laboratory at the seashore in

the field of operations, and accordingly a small station was opened on Puffin Island, a small bit of land off the northeast coast of the island of Anglesey, about 40 miles west of Liverpool, in a building formerly used as a semaphore station. The station was maintained here for five years, and the results of the explorations were published in Volumes I to III of the "Fauna of Liverpool Bay." The small size of the island and consequent limitations in the extent of the collecting grounds, together with its inaccessibility, made the selection of a new site imperative. Accordingly, in 1892, the station of the Liverpool committee was moved to Port Erin, Isle of Man, and the Puffin Island building was handed over to a local committee, with Prof. P. J. White as director. The station became less and less used and was finally entirely given up and the building dismantled in 1904.

BIOLOGICAL STATION AT PORT ERIN, ISLE OF MAN.

Director, Prof. W. E. Herdman, Croxteth Lodge, Ullet road, Liverpool, professor of natural history, University of Liverpool.

Curator, Mr. H. C. Chadwick, Port Erin, Isle of Man.

Assistant, Mr. T. N. Cregeen, Port Erin, Isle of Man.

A preliminary examination in 1892 revealed a rich and varied fauna and a sheltered harbor at Port Erin, on the southwestern end of the Isle of Man, directly accessible by steamer and rail from Liverpool. Accordingly arrangements were made by the Liverpool marine biological committee with the proprietor of a local hotel to build a biological station for them on the beach at the foot of the hotel grounds. This, the first station at Port Erin, was located at the head of the bay, just above tide level at the water's edge, at the base of the cliff. The building was formally opened June 4, 1892.

The local interest in the questions of the fisheries and in the station and aquarium aroused by Professor Herdman's work led in 1898 to an investigation by an industries commission, which recommended that the Manx government should promote practical fisheries investigation, and for that purpose establish a closer connection with the Port Erin station. Accordingly a committee of the Tynwald court, under the chairmanship of Deemster Kneen, met on June 16, 1901, took evidence, examined sites, conferred with the Liverpool committee, reported in favor of erecting a combined biological station, aquarium, and hatchery upon a site near the base of the ruined breakwater, and advised a grant of £2,000 for the construction of the plant and an annual grant of £200 for its support. The report was later adopted and the sums granted. It was arranged that the laboratory was to be under the complete control of the Liverpool committee, the hatchery under that of a committee of the Manx government, and the aquarium under joint control of both, the director and chairman of the Liverpool committee being recognized as director also of the hatchery.

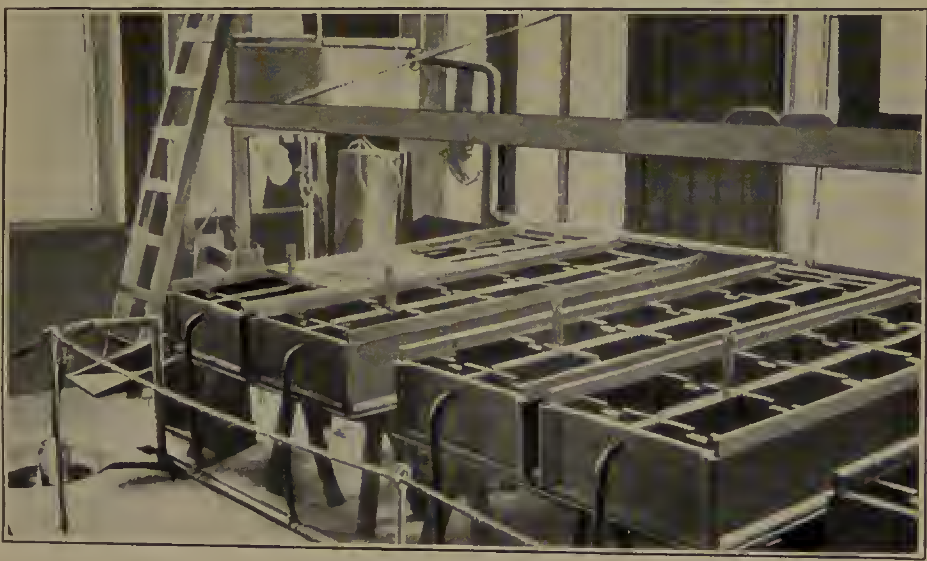
Beyond subscribing to the support of a single table (£10), the University of Liverpool has at no time had any administrative relation to the station, and this new affiliation with the fisheries interests still leaves the direction of the laboratory entirely in the hands of the Liverpool committee and preserves intact the original simplicity of administration.

The plans of the new building and its fittings were sketched by Professor Herdman, and construction was begun on November 4, 1901. The building was dedicated September 27, 1902. The laboratory is used primarily for research, but serves other interests whenever feasible. Its affiliation with the fisheries interests is not such as to absorb its funds and the time of its staff, the Piel laboratory and the fisheries laboratory at Liverpool serving these interests. The research activities of the station have been concentrated upon a programme of intensive study of the plankton of the Irish Sea by Professor Herdman for several years with the aid of *The Ladybird*. Summer courses in nature study are given by assistants of the university in the elementary laboratory at the station, and occasional public lectures are given here also. The aquarium is open to the public (admission 2d., children 1d., school children with teacher free), and an admirable illustrated guide (Herdman, 1905) is supplied at the small price of 3d. The school curriculum at Port Erin includes visits to and lectures at the aquarium. The aquarium is exceedingly popular, 15,576 people visiting it in 1907, yielding a considerable income in spite of the small price of admission.

The station is open throughout the year. Properly qualified investigators or advanced students are admitted on application to the director. A fee of 10s. per week is charged for the use of research tables. Subscribers are entitled to the use of a place for three weeks for each guinea of the subscription. Universities and institutions have the continual use of a table for a subscription of £10 per annum. The universities of Liverpool, Manchester, and Birmingham each support one table. A student microscope, the use of the collecting apparatus, and a limited amount of alcohol per week are provided for by the fee. Materials from dredging remain the property of the station. Special arrangements must be made for containers, preservatives, and collections taken from the laboratory. Some account of the results of investigations at the station is expected to be given to the Biological Society of Liverpool. The full rules and regulations are published regularly in the "Annual Reports."

The station at Port Erin is largely dependent for its upkeep on the annual subscriptions of its friends. The fisheries work in the hatchery is supported by a separate fund. The station receives the income of the British Association (1896) fund of £1,000 and has an endowment of £173. The station receives much gratuitous service.

A. EXTERIOR.



B. INTERIOR OF HATCHING ROOM, SHOWING DANNEVIG BOXES (EMPTY).

MARINE BIOLOGICAL STATION AT PORT ERIN.

Its budget is relatively very small. The receipts and expenditures in 1908 were as follows:

Receipts and expenditures, Port Erin biological station.

RECEIPTS.	£	s.	d.
Subscriptions and donations	119	11	6
Admissions to aquarium, share of	32	8	10
Sale of publications, specimens, etc	38	3	11
Rent of tables and fees	35	5	0
Interest on endowment and British Association (1896) fund	38	0	0
Miscellaneous	6	17	4
Total	270	6	7
EXPENDITURES.			
Salaries, share of	100	2	0
Printing	64	16	0
Upkeep, etc	105	8	7
Total	270	6	7

The new Port Erin station stands on the southern shore of Port Erin Bay, on the southwest coast of the Isle of Man, near the mouth of the harbor, on a shelf quarried out of the rock at the base of the cliff, about 21 feet above mean tide. The grounds included within the stone walls at the rear and iron railing at front of the building contain 23,400 square feet. The public character of the surrounding land insures the station against encroachment of private premises or industrial plants. The building stands at a distance of 150 feet from the water front with its main axis running east and west, and fronting north, looking across the mouth of the harbor with its ruined breakwater toward picturesque Bradda Head across the bay.

The station is a plain building of stone quarried on the site, with slate roof. It is two stories in height and has a frontage of 90 feet. It consists of a center block with front and rear gables, bearing the legend "Aquarium," and two wings; to the right the "Fish Hatchery," and to the left the "Biological Station." The outside and principal partition walls are 18 inches in thickness and are everywhere lined with varnished pine wainscoting, which gives the building a light and pleasing appearance. The main entrance in the central block (32 by 44 feet) leads through a vestibule (8 by 10 feet) to the centrally located aquarium hall (30 by 30 feet), open through the second story to the roof and lighted by large skylights. Upon the left and right sides of the vestibule, respectively, are offices (10 by 10 feet) for the director and curator, that of the latter having a door with inquiry window opening into the vestibule.

The aquarium hall has nine concrete tanks with masonry walls, faced with concrete, 18 inches in thickness, a solid bed of masonry and concrete beneath and plate-glass fronts 1 inch in thickness. The

upper edge of the glass rests against a pine timber 4 inches square, with a sheet-lead curtain. The center tank on the south wall has a front 7 feet in length, those on either side of it 6 feet, while the three on the east and on the west walls are but 4 feet 7 inches long. All of the tanks are 4 feet wide and 4 feet deep. The aquarium cement used is made of white and red lead and litharge in equal parts, by weight, well mixed with boiled linseed oil to the consistency of putty. The exposed edges are covered with gold size. Windows in the south wall admit light into the three larger tanks and into the two nearest them on the east and west walls. The other four receive their light only from the aquarium hall, a serious defect.

In the center of the room (Pl. XXXVI, *A*) is a table containing nine flat, open wooden tanks, used as aquaria for sea anemones, hydroids, mollusks, and tunicates, and other attached invertebrates.

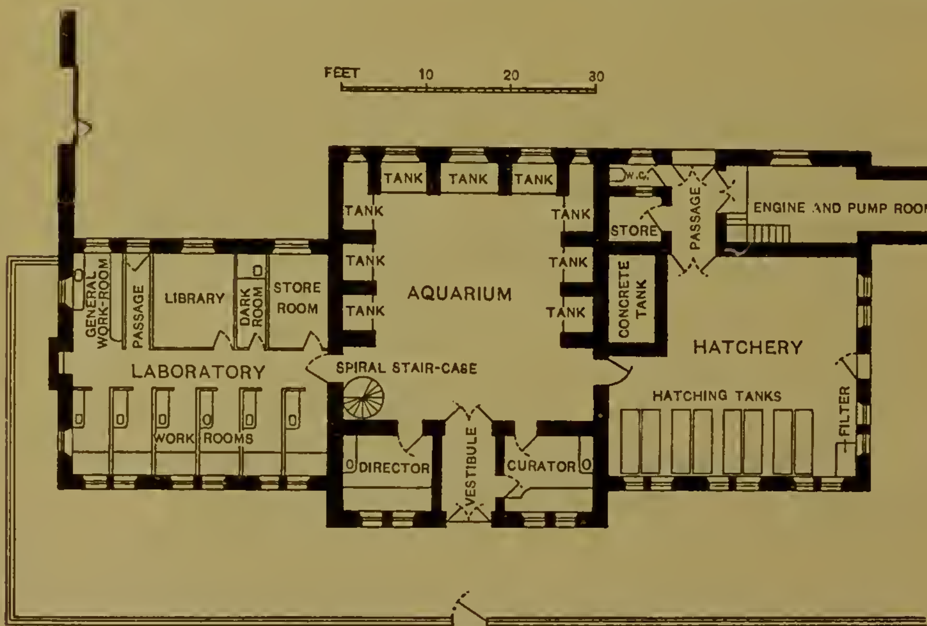
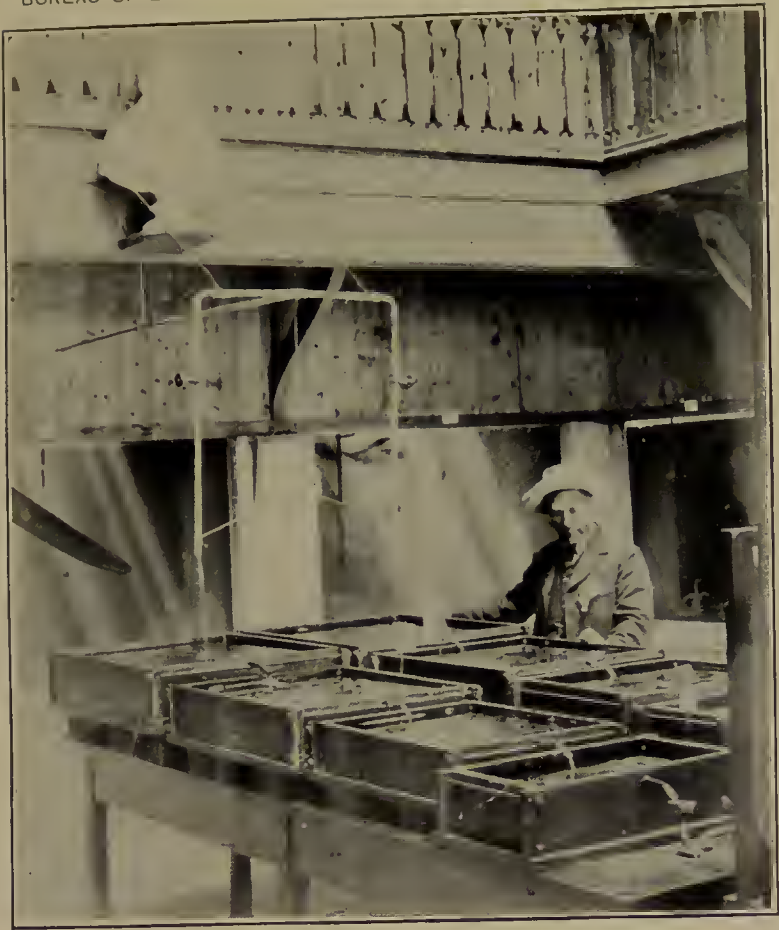


FIG. 20.—Ground floor of Port Erin biological station; after Herdman (1903).

They are simple wooden boxes stoutly made with mortised sides and base held together by galvanized-iron rods. For convenience in handling and storing they are made in nests, in the following sizes: 32 by 28 by 7 inches, 27 by 24 by 6 inches, 24 by 19 by 5 inches, and 24 by 12 by 6 inches. They are coated inside with a mixture of pitch and tar, laid on hot, and on the outside they are painted with lead paints. They are relatively inexpensive, water-tight, light, convenient, and very durable, the present equipment having been in almost constant use since 1893. They are stepped down in series, the uppermost receiving a spray of water and the overflow is carried by glass tubing down the series.

There are also three large aquaria with slate backs, sides, and bed, 3 feet 6 inches long, 2 feet 6 inches high, and 2 feet wide, with plate glass 0.5 inch thick. The tank aquaria (see fig. 20) abut directly



A. INTERIOR OF EXHIBITION HALL, SHOWING WOODEN BOX AQUARIA.

B. END VIEW OF THE STATION WITH SPAWNING POND IN FOREGROUND.

MARINE BIOLOGICAL STATION AT PORT ERIN.

against the wall of the building and there is no gallery for access to them from the rear. They are reached only through doors above the plate-glass fronts opening directly from the aquarium room, an arrangement which seriously interferes with lighting and the care of the tanks.

A door to the left leads into the laboratory wing (28 by 32 feet), which contains a main laboratory (15 by 30 feet), from which open a storeroom (7 by 12 feet), a dark room (4 by 12 feet), a library (10 by 12 feet), a workroom (6 by 12 feet), and a passage (3 by 12 feet) to the rear of the building. The main laboratory contains six cubicals (each 5 by 10 feet), separated by partitions 7 feet in height, each fitted with a shelf table fronting the single window, sink with salt and fresh-water supply, and abundant shelving. The room is heated by an open grate at the end.

The west wing (37 by 40 feet) contains the hatchery (27 by 30 feet), with eight Dannevig fish-hatching tanks (Pl. XXXV, *B*) along the wall, operated by a Scott-Johnstone tip bucket. (For a complete description of these see Herdman, 1909, and figs. 21–27.) A concrete storage tank or floor aquarium 9 feet 8 inches long, 5 feet 6 inches

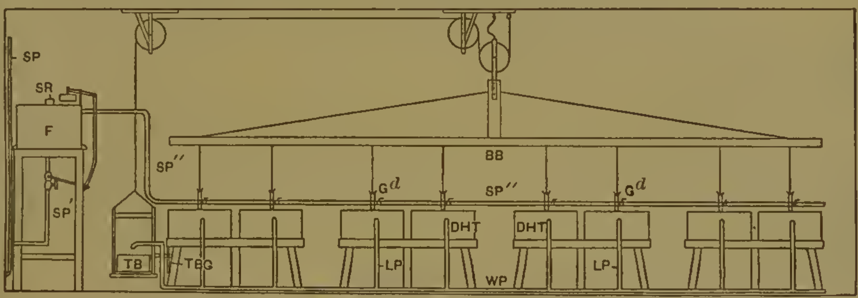


Fig. 21.—Elevation of filter, Scott-Johnstone tipping-box, hatching tanks, and oscillating apparatus.

wide, and 3 feet deep, and walls 17 inches thick is placed in one corner. A passage leads to the storeroom (5 by 6 feet), engine room (9 by 27 feet), and to the rear yard, and a door to the west leads directly to the hatchery pond.

The upper floor of the building is reached by a spiral iron staircase, which ascends from the northeast corner of the aquarium hall to the spacious gallery lighted from above and by north and east windows. The balustrade supports a series of desk cases for the exhibition of museum specimens, while around the walls are cupboards and cases for herbarium and museum collections. Against the balustrade stands a fine bust of Edward Forbes, the pioneer explorer of the Irish Sea. The large room in the east wing (30 by 32 feet) is fitted up as a lecture room and elementary laboratory, and the corresponding room in the west wing serves as a storeroom for nets and tackle.

Within the walled area to the west of the building a spawning pond (50 by 90 feet) (Pl. XXXV, *B*) with a depth of 2 to 9 feet has been excavated in the solid rock. Its capacity is 150,000 gallons. It is

divided into two parts by a cross wall with a regulated sluiceway, and is used for the confinement of the spawning plaice.

The water supply of the station is drawn from the harbor through a 4-inch cast-iron pipe, 270 feet in length, carried to a clean rock on the beach below half-tide mark, where it ends in a perforated wooden rose box. The pump is of three-plunger vertical type capable of delivering 4,000 gallons per hour and is run by a 3-horsepower Crossley gas engine. The water is pumped into two irregular reservoirs with masonry walls faced with concrete. The upper cistern, with its floor 33 feet above the sea and 12 feet above the laboratory

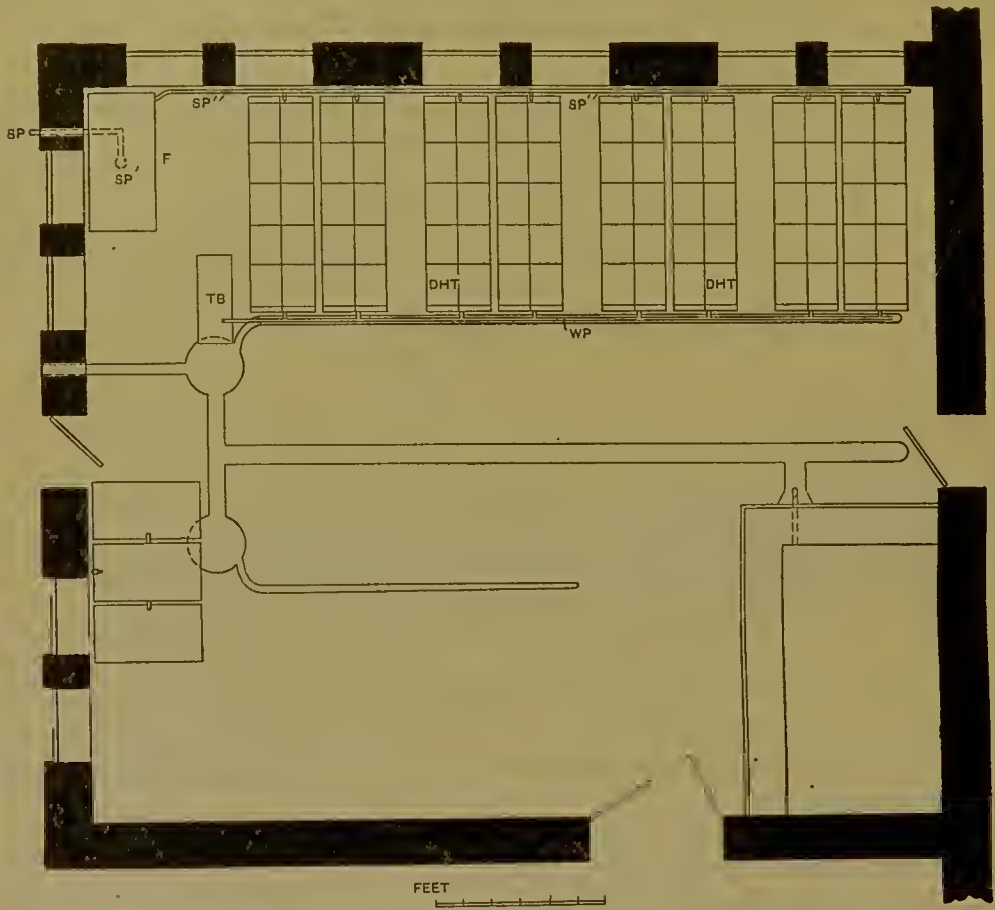


FIG. 22.—Ground plan of hatchery and tank. Same scale as fig. 21.

floor, has a capacity of 11,000 gallons, and the lower (with its floor 5 feet below that of the upper cistern) of 16,000 gallons. Three-inch galvanized-iron pipes conduct the water to and from the cisterns, and galvanized piping is used throughout the distributing system. This was thoroughly galvanized after fitting and has stood since construction without visible trouble from rust. The valves and the cocks are of brass, but as few as possible are used in the system. The terminals are cocks of brass connected with Sprengel tubes of rubber hose and glass (fig. 21) and are used to deliver a mixture of water and

air through glass tubes to a depth 1 foot above the bottom of the aquarium. Overhead jets are for the smaller used open aquaria.

The aquaria at Port Erin are among the most thriving in European stations. The purity of the water and the care taken with the piping and the stocking of the aquaria are such that animals live for years in the aquaria without disaster. The fish are fed daily on raw mussels, herring (chopped fine), and the anemones weekly upon crabs or

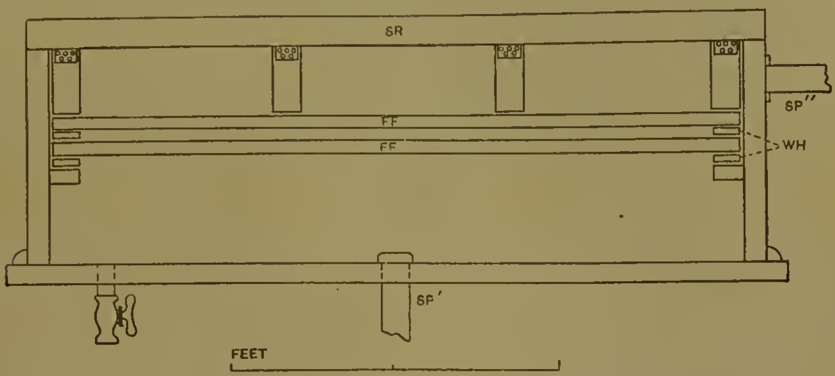


FIG. 23.—Sectional view of filter box (F, fig. 21).

fish. The display of anemones in the open wooden aquaria is noteworthy for its variety and beauty. The walls of the cement aquaria are covered by normal growths in situ of hydroids, bryozoans, worm tubes, and sponges, incrusting forms of the latter forming beautiful circular colonies nearly 2 feet in diameter. Even a few small seaweeds have grown in the tanks, but the metal used in the valves is probably inimical to their continued growth. Considerable trouble has been caused by the growth of organisms in the pipes also.

FIG. 24.—Hatching tank (DHT, fig. 21), seen from above.

The equipment of the Port Erin station is simple and inexpensive, in so far as the chemicals and glassware are concerned. There are eleven microscopes, one large Ross, and ten Beck student stands, three dissecting microscopes, incubator, and rocking and sliding microtomes.

The marine equipment is most excellent and is kept in prime order. The station has the use to some extent of a private steam yacht, *The Ladybird*. She is a schooner-rigged steamer of 36 tons yacht measurement, 69 feet in length, 11 feet 8 inches beam, 6 feet draft, with engine of 55 horsepower and a speed of 9 knots per hour. She carries a crew of three men and is fitted with a steam capstan and about 100 fathoms of dredging cable. Row and sail boats for harbor

and shore collecting are readily hired at Port Erin, so the station maintains no fleet of its own. The equipment of gear and tackle for collecting is excellent and well selected. In addition to trawls, dredges, and apparatus for shore collecting there are the following: An otter trawl, a Petersen's young fish trawl, Nansen closing net, a Scheerbrutz net, Apstein nets, Hensen vertical net, tow nets of various sorts,

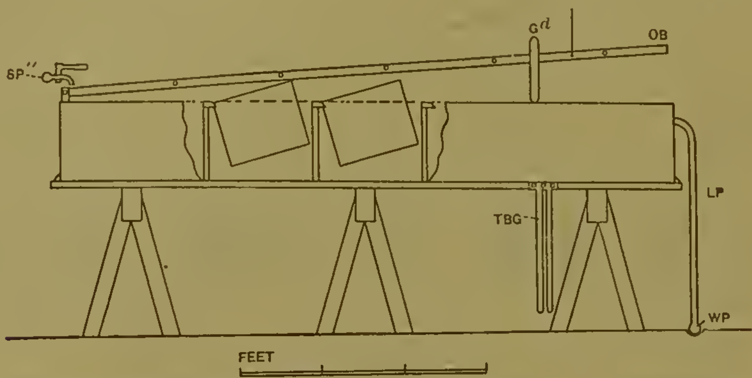


FIG. 25.—Side view of hatching tank, showing two boxes in position, with oscillating bar raised.

seines and a large assortment of fish traps. The hydrographic equipment consists of certified surface and deep-sea thermometers of the international commission and water bottles of the Mill, Buchanan-Richard, and Ekman patterns.

The library consists of 220 volumes and many pamphlets dealing with the local fauna. The excellent library of the Liverpool Biological Society is available as needed by investigators at the station.

The beginning of a collection of the local fauna has been made, but as yet it is far from complete.

The sea around the Isle of Man is classic ground to the marine biologist, for it was here that Prof. Edward Forbes, one of the pioneers in marine exploration, made his first cast of the dredge, and later carried on more extensive explorations. It has remained, however, for the energetic director of the Port Erin station to make the Irish Sea one of the most thoroughly explored waters of the globe.

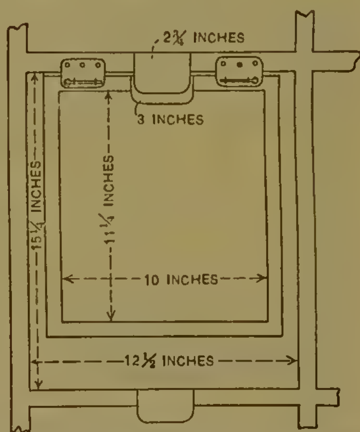


FIG. 26.—One compartment of hatching tank, with box hinged in position, seen from above.

An excellent description of the environmental conditions and the characteristic fauna and flora is to be found in Professor Herdman's (1896) biological accounts of Liverpool and the Isle of Man prepared for the Liverpool meeting of the British Association, from which I quote:

"The Isle of Man is interesting ground to the marine biologist, as it presents, within a very limited area, seacoasts and sea bottom of very varied characters, and a wide range of depth. There are cliffs and reefs of sandstone, limestone, and hard metamorphic rocks; there are sandy bays, gravel beaches, and mud flats; and, within a distance of 12 miles from the shore there are depths up to nearly 80 fathoms. This permits of a great variety in the marine fauna and flora, especially around the southern end of the island, where, within a radius of about a mile from the Port Erin biological station many different kinds of shore and sea-bottom are met with.

"On account of the set of the tides, Port Erin Bay and the sea around the Calf receive directly the water which has come up the center of St. Georges Channel, unpolluted by contact with land, and undiluted by the entrance of any large streams. Consequently the sea off the south end of the Isle of Man is of very high specific gravity (over 1.027) and of great purity. Many of the food fishes of the Irish Sea come there to spawn, and the pelagic fauna caught in the surface tow-nets is abundant, and at certain times contains oceanic or southern organisms (such as Siphonophora), which have been carried in from the Atlantic."

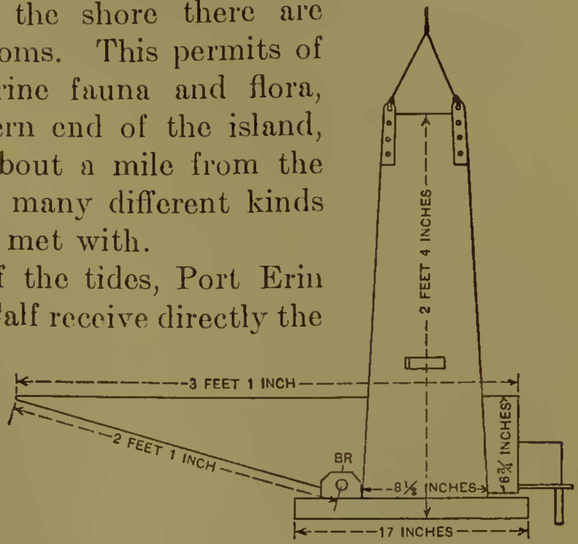


FIG. 27.—Side view of tipping box and frame.

Abbreviations in figs. 21–27: BB, balanced bar attached by wires over pulleys to tipping-box (TB) and by vertical wires, horizontal oscillating bars (OB, fig. 25) resting on hatching boxes; BR, bearings of tipping box; DHT, Dannevig hatching tanks; FF, filter box; FF, filters of Turkish toweling; Gd, iron guides for oscillating bar (OB, fig. 25); LP, lead discharge pipe; OB, horizontal oscillating bars; SP, SP′, SP″, supply pipes for sea-water, with filter box (F) interposed between SP′ and SP″; SR, bar of wood on top of filter adjusted to regulate valve in supply pipe SP′ below filter box; TB, tipping box balanced on bearings (BR, fig. 27); TBG, tipping box guides; WH, washer between filters; WP, waste pipe.

The extreme amplitude of the tides at Port Erin (10 feet 6 inches at neap and 22 feet at spring) affords excellent collecting grounds with tide pools, rocky reefs, ocean caves, limestone reefs, mud and sand flats, within easy reach of the station. The dredging is excellent. Over 150 species were taken in one trawl haul off Calf Island. The plankton in the harbor and channel outside is rich in both neritic and oceanic forms. Some commercial fishing is carried on at Port Erin and the adjacent Port St. Mary. Upward of 2,000 species have thus far been reported in the marine fauna and flora of the Irish Sea and most of them are available in the neighborhood of the Port Erin station. The fauna includes, for example, 20

species of Actinians, 35 Echinoderms, 190 Copepoda, and 112 marine fish. Perhaps no other European station has so complete and compact a handbook of the local fauna and flora as will be found for the Port Erin station in the "Fauna and Flora of Liverpool Bay."

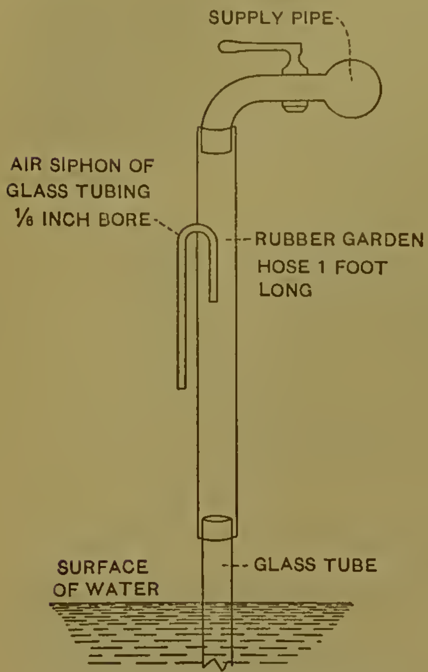


FIG. 28.—Aerating device in Port Erin aquaria.

The Port Erin station by reason of the purity of the water and richness and great variety of the fauna offers unusual attractions to anyone wishing to do experimental or observational work on living animals, or to carry on developmental or cultural studies. It is to be hoped that the future may see a greater development of its provisions for research in these lines in the way of more ample research rooms with a generous equipment of cultural aquaria.

Literature: Herdman, Annual Reports (1886–1908, 1896), Dean (1894), Hartlaub (1902), Sand (1897), Dakin (1908).

LANCASHIRE AND WESTERN SEA FISHERIES COMMITTEE.

Superintendent, J. Travis Jenkins, D. Sc., 16 Walton's Parade, Preston, England.

Honorary director of scientific work, Prof. W. A. Herdman, Zoological Laboratory, University of Liverpool.

Resident naturalist and fisheries assistant at Piel-in-Barrow, Mr. Andrew Scott.

Fisheries assistant at Liverpool and on the *James Fletcher*, Mr. James Johnstone.

This committee, appointed by the county council and a part of the board of trade, has in charge the administrative affairs of the sea fisheries of Lancaster and adjacent counties, including the hatcheries and scientific investigations. It maintains a fisheries laboratory at the University of Liverpool and a biological station and hatchery at Piel-in-Barrow (under the direction of Professor Herdman). It also owns an investigating steamer, the *James Fletcher*, employed likewise in policing the protected waters. It depends entirely upon local support and receives no national funds. A quarterly series of reports is issued.

The fisheries laboratory is housed in the zoological laboratory at the University of Liverpool. In it are conducted investigations upon the food and other fishes of the Irish Sea. The fisheries, hydrographic, and plankton work of the *James Fletcher* is directed from this laboratory and the collections are received here for investigation.

The fisheries investigation steamer the *James Fletcher*, launched in 1907, is a twin-screw, schooner-rigged, two-masted vessel of 263 gross tonnage. Her length is 139 feet and beam 23 feet. She has triple-expansion engines, an indicated horsepower of 600, and a speed of 12 knots per hour. She is well equipped with beam and otter trawls, dredges, and plankton nets, a Petersen young-fish net, a Scheerbrutz net, and an equipment of the international instruments for hydrographic work.

Literature: Reports (1908).

BIOLOGICAL STATION AND FISH HATCHERY AT PIEL-IN-BARROW.

Director, Prof. W. A. Herdman, University of Liverpool.
Resident naturalist, Mr. Andrew Scott, Piel-in-Barrow.

The station was opened in 1896 as a sea-fish hatchery and in the following year developed as a biological station. It is located on Roa Island, in Barrow Channel, a branch of Morecombe Bay, in the little fishing village known as Piel, 5 miles from Barrow. It is connected with this city by a railway embankment. Several trains daily, each way, give communication with the mainland.

The station occupies a former seaside residence, the Villa Marina, a large brick dwelling house, which has been remodeled for laboratory purposes. The building contains ample living quarters for the resident naturalist and for visiting students or investigators, and in addition a well-lighted and fully furnished naturalists' laboratory or research room, a general laboratory accommodating fifteen to twenty students, and a bacteriological laboratory. There is a good equipment of Leitz's microscopes, charts, diagrams, and well-arranged collections of the local fauna, especially of the fishes. A former lifeboat house contiguous to the villa has been converted into a hatchery and tank room, with several large cement aquaria and Dannevig hatching boxes with a Scott and Johnstone tip-bucket. Two storage cisterns of 2,500 gallons capacity each are located in the loft. Water is pumped by a 4-horsepower Crossley gas engine through a 5-inch galvanized-iron sea pipe, carried to the beach to a point 6 feet above low water. The distributing system is of galvanized iron, thoroughly galvanized after fitting.

The environmental conditions at Piel are peculiar. There is a tidal amplitude of 30 feet at spring and 19 feet at neap tides. In consequence of this there is fine rock collecting on the shores of the adjacent Piel Island, and mud and sand flats and mussel beds of vast extent are exposed at every tide. On the rocks, marine algæ, including *Laminaria*, are found in abundance. Echinoderms, worms, and mollusks are very abundant and easily obtained in variety. Piel is adjacent to great mussel, cockle, and periwinkle fisheries. Owing to the wide expanse of tidal flats and extreme tidal amplitude,

the water at Piel is often turbid and must be filtered through blankcts before being used in the hatchery and aquaria. It is, however, relatively free from serious sewage contamination.

The station is open throughout the year. Properly qualified investigators are admitted on application to the director without charge, except for 15s. per week for board and lodging. The picturesque location, commanding view, wide verandas, roomy laboratory, quiet and seclusion of the building, and the exceptional shore and mud flat collecting, to say nothing of the cordial welcome accorded to the occasional biological pilgrim, lend a peculiar attraction to the Piel station.

Classes in nature study and marine biology are held at the station in the evening and on Saturday afternoons for teachers in the public schools. Three grades of work are offered, each extending through a month. This work is supported by grants from the local school boards.

The most unique feature of the Piel station is the institution of fishermen's classes. These have been held every spring for the past ten years during the spawning season from March to May. These were formerly held at the University of Liverpool, but are now held at Piel station. Usually four classes are held, each of two weeks' duration, and the number admitted to each is limited to sixteen. The instruction is given by Messrs. Scott and Johnstone, of the laboratory staff. A syllabus outlining the instruction offered has been published by Mr. Johnstone (1903) in the "Fisheries Laboratory Report." The course of study includes a few fundamental biological principles and outline of the structure and life history of the fish, shrimp, crab, mussel, and cockle, the food relations of marine animals, the plankton, and the parasites and enemies of fishes.

The fishermen who attend these classes are allowed £5 each in lieu of expenses and wages for the two weeks of their attendance. The work is supported by grants from the education committee of the county and special grants from the cities concerned. The men who attend are chosen by the fishermcn of their own locality. The nominations are often eagerly sought, and students sometimes return to repeat the work. Young and old both come, the record being held by one weather-beaten tar of 80 years, who wrestled successfully with a compound microscope and a dish of wriggling plankton. The work is taken in a serious spirit, and not the least valuable parts of the course are the adjourned sessions to the veranda, where the secrets of nature are discussed over a consoling pipe and a mutual interchangc of fact and opinion finds free play. These fishermen's classes afford a basis not only for the education of a few fishermen in some elementary biology, but they lay a broad foundation for a mutual understanding between the toilers of the sea and those who seek most

wisely to preserve the resources of British waters. The cooperation of the fishermen in the enactment and enforcement of restrictive legislation and in the development of new resources is the more readily secured and maintained because of the annual gatherings at Piel.

Literature: Reports of the Lancashire Sea-Fisheries Laboratory; Reports of Superintendent, Lancashire and Western Sea Fisheries District.

MILLPORT BIOLOGICAL STATION OF THE MARINE BIOLOGICAL ASSOCIATION OF THE WEST OF SCOTLAND.

President, Henry Barr, B. L., 45 West George street, Glasgow.
Secretary and treasurer, George Middleton, M. A., LL. B., 83 Bath street, Glasgow.
Superintendent of the station, Richard Elmhirst, Keppel Pier, Millport.

The Millport biological station owes its origin ultimately to the *Challenger* expedition on the one hand and on the other to the life-long enthusiasm of Dr. David Robertson, "the Cumbræ naturalist," known for many years as a student and collector of the marine life on the shores of his island home. In June, 1885, the *Ark* and the *Medusa* were sent from the Granton station [see Cunningham (1885), Van Beneden et Renard (1884), and Hoyle (1888)] through the Forth and Clyde Canal to an anchorage in Millport Bay on the Isle of Cumbræ. It was the intention to move the *Ark* from place to place on the west coast and make a survey of the western waters. In Millport Doctor Murray found in Doctor Robertson a sympathetic fellow-worker and helpful coadjutor. The excellent facilities here for marine investigation and the central location in the Clyde area led finally to the *Ark* being drawn up on the beach near the mouth of Millport Harbor, where she remained until she met a complete and not unfitting destruction in the terrific gale on the night of December 20, 1900, which also wrought some damage to the newly established Millport station. The *Medusa* and the *Ark* were used for several years in physical and biological explorations in the Clyde area by Doctor Murray and Dr. H. R. Mill, and upon the presentation of the results of the survey at the meeting of the Philosophical Society of Glasgow on March 31, 1886, Doctor Murray offered to hand over the vessels with their scientific equipment to any organization that would undertake to use them for scientific purposes. No offer appearing, the *Medusa* returned to the east coast and the *Ark* remained on the beach and became the working laboratory of Doctor Robertson. Finally, in 1894, largely through the instrumentality of Doctor Robertson, a committee of Glasgow scientists and business men was formed, to whom the *Ark* was formally transferred by Doctor Murray, and it was opened as a scientific laboratory for visiting scientists and as a museum to the public, material from the collections of Doctor

Robertson and Doctor Murray being placed on exhibition. In 1894–1896 31 persons, exclusive of the committee, made use of its laboratory facilities for study or research and over 5,000 people visited the museum.

The popularity of the enterprise led the committee to undertake to secure funds for the erection of a permanent building for a marine station. In 1896 an appeal to the public for funds was made, which ultimately yielded £300. A generous donation of £500 from Dr. Thomas Reid, Waltonian lecturer in the University of Glasgow, made it possible to proceed at once with the enterprise. A site was secured from the Marquis of Bute for a merely nominal rental near Keppel Pier, Millport, and on August 7, 1896, the first sod for the foundation was cut by Doctor Robertson, and on October 17 the foundation stone was laid by Doctor Reid. The leader in the station project did not, however, live to see the fruition of his efforts, for the friends of the enterprise mourned his loss by death on November 20. The station buildings were formally opened on May 15, 1897, by Sir John Murray. Doctor Robertson's collections were given to the station and are housed in the museum which bears his name. An artistic tablet of hammered copper placed in the wall of the museum commemorates his services to the Millport station.

The subsequent history of the station has been one of generous and prompt response to meet urgent calls for running expenses or additional equipment. Thus, a photographic dark room, a steam heating plant, and other minor improvements to the building and grounds, a concrete boat slip, gas fittings, and much valuable apparatus have come to the station through the benefactions of its many friends. A dredging steamer with her equipment and an extension to the laboratory with a full equipment of aquaria and the necessary reservoirs and circulating system have been installed, the library has been increased, and a director's cottage has been built at a total cost of over £6,000 through the generosity of Mr. James Coats, jr. Upon the death of Doctor Robertson, his son, Mr. David Robertson, continued his father's interest in the station till his death in 1901. The subsequent development and equipment of the station is due in no small part to the painstaking efforts of Prof. James F. Gemmill, of Glasgow University, president of the association from 1899 to 1907. The honorary president of the association from 1900 was Sir John Murray, and since 1904 the lord provost of the city of Glasgow.

When the *Ark* was left in Millport in 1887 Capt. Alexander Turbyne was left in charge by Doctor Murray as curator and collector, and he continued in this position until 1898, when he was succeeded by Mr. Alexander Gray in the curatorship of the new laboratory. In 1903 Mr. W. T. Gibson was appointed curator and Mr. John McKenzie assistant curator, but both resigned at the close of the

year and were succeeded by Mr. Stephen Pace, formerly assistant director of the station at Plymouth, who took up his work in July, 1905. Owing to the differences between the director and the majority of the general committee having charge of the affairs of the station over fundamental questions of the policy of the station, especially in the matter of research along the line of a biological survey, Mr. Pace resigned his position in October, 1907, and Mr. Richard Elmhirst, naturalist of the station, was appointed as superintendent in charge. Prior to this the staff of the station consisted of a director, a naturalist, a museum attendant, a laboratory attendant, a skipper, and an engineer. The withdrawal of a number of the scientific supporters of the station from official connection with it followed Mr. Pace's resignation.

The Millport station has been and still is unique among European stations in the large number of individuals interested in its work and contributing to its support. In 1905 the Marine Biological Association of the West of Scotland had 182 subscribing members, while in addition thirteen scientific societies, five educational institutions, and the municipal authorities of three cities were contributors.

The constitution of the association provides as follows for the organization and administration of the Millport station:

> The objects of the association are the investigation of the marine fauna and flora of the district known as the Clyde Sea area, the establishment, endowment, and maintenance of a biological station at Millport, or on such other part or parts of the west coast of Scotland as may from time to time be found convenient or desirable, and generally the fostering and encouragement of biological research.
>
> These objects are to be promoted by the provision, equipment, and maintenance of the station, the formation of a museum and library in connection therewith, the holding of meetings in Glasgow or elsewhere, the collection and preservation of specimens, the publication of lists of the marine fauna and flora of the district, and of proceedings, reports, and the like.

The membership of the association is open to all having these objects at heart. New members must be proposed and seconded by two members of the association, and the executive committee deals with all applications for membership.

The minimum annual subscription of members is 1 guinea, but larger subscriptions carry special privileges in the matter of admission to the aquarium and the use of research tables.

The heritable property and all funds belonging to the station are vested in a body of trustees. These trustees are appointed by the general committee and hold office during life.

The whole affairs of the station are managed by a general committee consisting of (1) the trustees above mentioned, (2) not less than ten or more than fifteen elected members who retire triennially in rotation, but are eligible for reelection, and (3) twenty-one representative members elected annually by the public bodies in Glasgow

and neighboring towns as follows: Six from educational institutions, three from school boards, two by municipal authorities, and ten by scientific societies.

University of Glasgow.
University of Edinburgh.
University of Aberdeen.
Corporation of the City of Glasgow.
School Board of Glasgow.
School Board of the parish of Govan.
Faculty of Physicians and Surgeons in Glasgow.
Royal Philosophical Society of Glasgow.
Anderson's College Medical School, Glasgow.
Natural History Society of Glasgow.
Geological Society of Glasgow.
Andersonian Naturalists' Society, Glasgow.
St. Mungo's College, Glasgow.
Microscopical Society, Glasgow.
Glasgow University Medico-Chirurgical Society.
Paisley Philosophical Society.
Paisley Naturalists' Society.
Paisley Branch Committee.
Greenock Natural History Society.
Buteshire Natural History Society.
Town Council of the Burgh of Millport.

The officers of the association are elected at the annual general meeting and consist of honorary president and vice-presidents, president, vice-presidents, honorary secretary, honorary treasurer, librarian, and auditor. The details of the management of the station at Millport are looked after by an executive committee appointed by the general committee.

Not only the first cost of the buildings and equipment, but also the expense for upkeep have been drawn largely from private subscription. In 1907 the receipts and expenditures of the Millport station were as follows:

Receipts and expenditures, Millport biological station.

	£	s.	d.
RECEIPTS.			
Reserve and cash on hand	765	13	5
Subscriptions, donations, and endowment	613	14	7½
Grant from city of Glasgow	100	0	0
Teachers' classes (two years)	254	9	1
Rent of tables	42	0	0
Sale of specimens and publications	3	11	4
Admissions to aquarium and museum	17	9	2
Total	1,797	2	7½
EXPENDITURES.			
Salaries and labor	546	19	1
Teachers' classes (two years)	162	5	3
Supplies, printing, upkeep, etc	215	12	6½
Upkeep of the *Mermaid*	91	13	1
Library, building and repairs	552	14	6½
Total	1,594	10	9

Classes in botany, zoology, and nature study for the teachers in the secondary schools have been conducted each summer in July–August at the station with instruction from the faculties of the uni-

versities, technical schools or medical colleges of Glasgow or elsewhere in Scotland. The work is arranged in grades for students attending the summer courses for the first, second, or third season. Up to 1908 a grant of £2 for a fortnight's attendance was made by the school board to each teacher attending the courses, and a further grant was made to the station for the expense of instruction and cost of materials and excursions. Each student pays an examination fee of 5s. From thirty to fifty students yearly have attended these courses, but with the withdrawal of the teacher's subsidy in 1908 the attendance fell off considerably.

The station is open throughout the year for research. There are twelve tables, three in separate rooms and nine in cubicals, for the use of investigators. The universities of Aberdeen, Edinburgh, and Glasgow, the school board at Paisley, and the town council at Millport each support, or have supported, a table (annual charge £10 10s.), and there are two tables under private subscription. Members of the association have the privileges of a table according to the amount of their subscriptions. The charges for short periods are £1 11s. 6d. per month and 10s. 6d. per week. These charges cover the use of a research room, ordinary reagents, the loan, at the discretion of the superintendent, of the various scientific instruments, including microscopes and the exclusive use in the tank room of one or more tanks. Reagents, alcohol, and containers used for material taken away from the laboratory are charged at moderate prices. Applications for admission to a research table should be made to a director, giving at least a week's notice. A full account of the regulations for workers at the station will be found in the annual report for 1907. About thirty investigators made use of the research tables each year.

The station offers to furnish to investigators for research purposes such material as can be readily supplied without charge on application to the superintendent. A price list of material for class use and for the museum is found in the annual report for 1907.

In addition to its contributions to research the Millport station has undertaken a unique public service, without parallel among other European stations, namely, the scientific entertainment of classes from the public schools, colleges, and universities, and of field clubs and naturalists' societies, and even to excursions of railway employees. In 1905 there were 31 such visitations. In addition to this there are six "open" dredging excursions, to which members of the association are invited, as well as being welcome to the regular collecting trips of the *Mermaid*, on application.

The public is admitted to the aquarium and museum at a nominal fee, three pence, or the museum alone for one pence, during the summer season, April to September. From 7,000 to 8,000 persons derive pleasure and profit from these exhibits annually.

The Millport station bears no administrative relation to any educational institution, beyond the official representation by single delegates of six institutions of higher learning in its general committee of approximately 50 members. In other capacities other members of the faculties of these institutions serve on the committee. The station does not undertake any research in connection with the fisheries or have any representative of these interests in its administration or personnel. Neither does it give any elementary instruction to fishermen's classes.

The station issues at present no publications save an annual report (1896+) of administrative character. In 1896 a volume of "Communications from the Millport station" was issued, but the series has been discontinued, and the policy of issuing reprints of papers, based on research at the station and published elsewhere in various journals, was for the time adopted. In 1901 a "Handbook" of the station was issued by the honorable secretary, Mr. J. A. Todd.

The wide interest manifested by the public in the Millport station and the ever ready and ample support which it has received, not only from several large donors, but from a wide circle of friends are gratifying indeed to all who are interested in the cause of marine biology. This wide interest and the means taken to develop and preserve it, together with the diffuse organization of the administration of the station, have brought certain consequences in their train which have interfered seriously with the development of its scientific work. In the first place, in the construction of the station building those parts designed for the popular uses—the public aquarium, museum, and elementary class room—utilize the larger and better parts of the building and the research rooms, especially the cubicals, are small and poorly lighted, as is also the tank room assigned for the purposes of investigation. The Millport station suffers in contrast with others in these particulars. Again, the cumulative effect of the constant and repeated demands upon the resources of the station and upon the time of the staff in ministering to the popular and amateur interests has been sufficient to detract seriously from the efficiency of the station as an instrument for the permanent advance of the science of marine biology and to limit its attractiveness to investigators. The conflict between the scientific and the popular interests reached a culmination at the seventh annual meeting on March 27, 1907, when the general committee voted by a majority that it did "not approve of the staff being employed in a biological survey." The effect of this resolution was to withdraw the funds of the station from the promotion of continuous investigation by the staff and to render the directorship no longer attractive to a working investigator. This action was followed by the resignation of the director and the with-

drawal of many of the scientific friends of the institution from active participation in its affairs. It is to be hoped that the committee, in charge of the station, can evolve some system of control that will insure a stable scientific policy of wide scope with adequate protection to the scientific interests involved, and at the same time preserve and develop the interest of the intelligent public in its field of investigation.

The Millport marine biological station is located on the Greater Isle of Cumbræ in the Frith of Clyde, about 27 miles from Glasgow, and is easily reached from that city by rail to Wemyss Bay or Largs and steamer thence to Keppel Pier, Millport. The station is on the eastern shore of the island hard by the pier. It stands about 150 feet from the rugged, rocky shore at an elevation of 18 feet above mean tide level. Its location is most picturesque, nestling beneath the famous "Deils Dyke" in the cliff which overtowers it at the rear. The grounds are limited to the immediate proximity of the buildings and contain but 3,800 square yards and are inclosed by a stone wall with iron fence in the front.

The buildings consist of the station proper, a seven-room curator's house containing a students' dining room, a storehouse, and an engine house. The station building is a substantial two-story structure of red sandstone after the Romanesque style. The original building was rectangular in form (30 by 68 feet) (fig. 29), with its long axis northwest by southeast, with the main entrance through veranda and porch at the southeast end. From the porch stairs ascend directly to the museum (30 by 52 feet) on the second floor. A door leads from the lobby into the hall, whence open the office or secretary's room (12 by 18 feet) and the superintendent's laboratory, the chemical room and a research room, three separate rooms (10 by 14 feet), and into the large research room (25 by 30 feet), containing nine cubicals (5 by 8 feet), each fitted with simple table and shelving and supplied with gas and heated by overhead hot-water pipes.

The research rooms are inadequately lighted by the single narrow window, are too small, have no proper water supply, while the combination of cement floor and overhead heating pipes is far from hygienic in cold weather.

A wide central passage leads to a sink and dark room at the rear, whence a door opens into the research tank room (14.5 by 21 feet), containing a row of six white glazed fire-clay sorting tanks and a double row of five pairs of aquarium tanks with middle shelf for glassware. (Pl. XXXVII, *B*.)

An extension (30 by 40 feet) to the original building provides the public aquarium room (38.5 by 22) (fig. 29), the rear stair to the

second floor (fig. 30), and the lavatories. The aquarium room contains a row of nine shallow glazed tanks along the north and east sides below the windows and a central bank made up of a double row

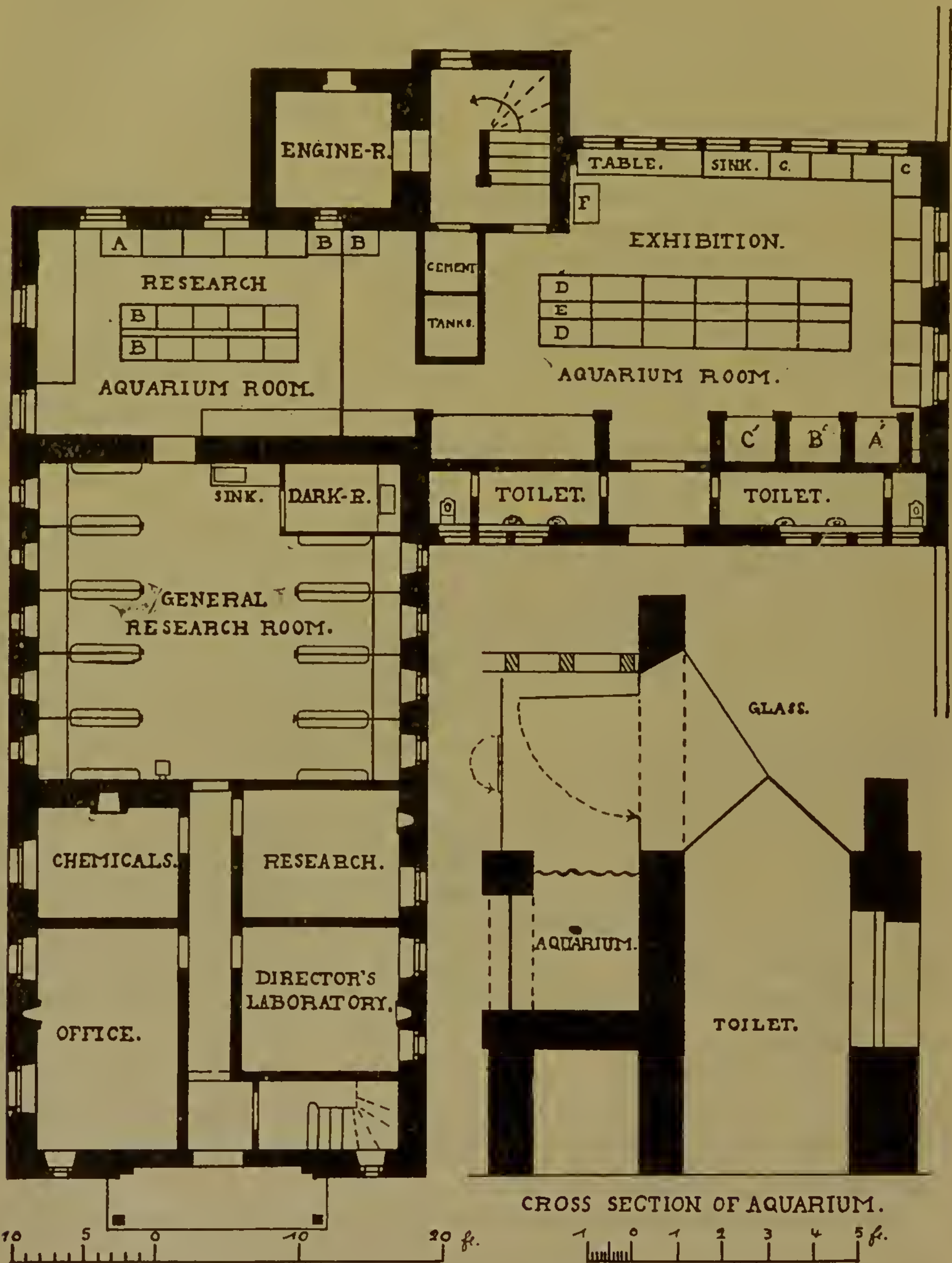


FIG. 29.—Ground floor, Millport biological station.

of six larger tanks with a single row of glazed tanks with glass faces on two sides at the height (of bases) of 4 feet 2 inches to 3 feet 5 inches from the floor.

Along the southeast wall is a row of four cement tanks with plate glass fronts. There are three small tanks in the right bank and one large one in the left. They are made of concrete; the smaller ones are 4 feet 9 inches high and all are 3 feet 3 inches wide and 2 feet 10 inches in depth, with walls 12 inches and bed 8 inches in

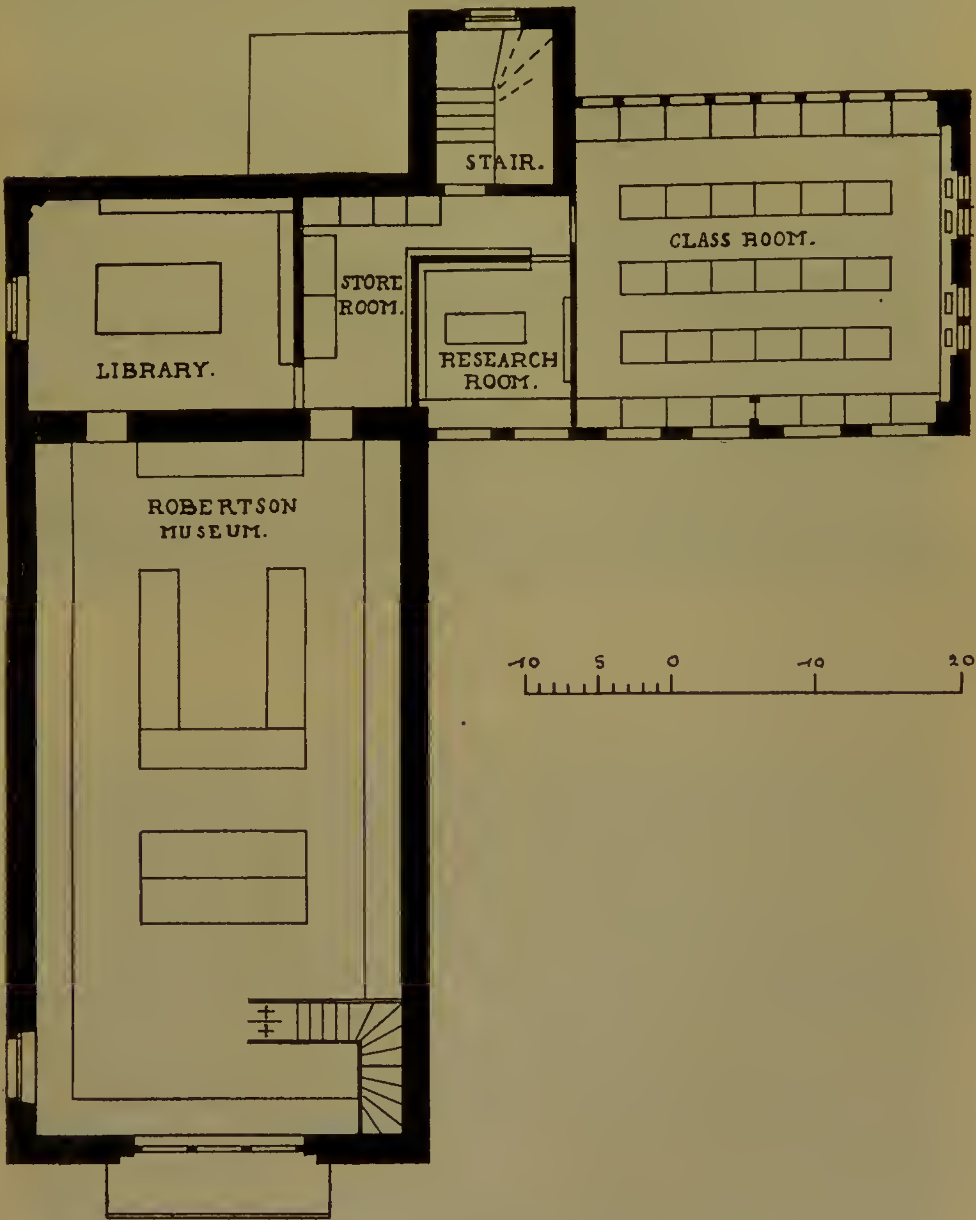


Fig. 30.—Upper floor, Millport biological station.

thickness and plate glass fronts 1 inch thick. The aquaria are well labeled throughout on tablets of white opal glass with rough surface, held in lead frames. The legend is written with a soft lead pencil, and can be erased or changed. The aquarium room is abundantly lighted by continuous windows on the northwest side and two double

windows to the northeast, and the large tanks receive light from oblique windows placed above the lavatories. (See cross section, fig. 29.) An opening in the wall above the aquaria provides for access to the large tanks from the public room for attendance and regulation of the light by means of a swinging door.

The smaller aquaria of the Millport station are so excellent in many ways and so unique as to merit special description. They

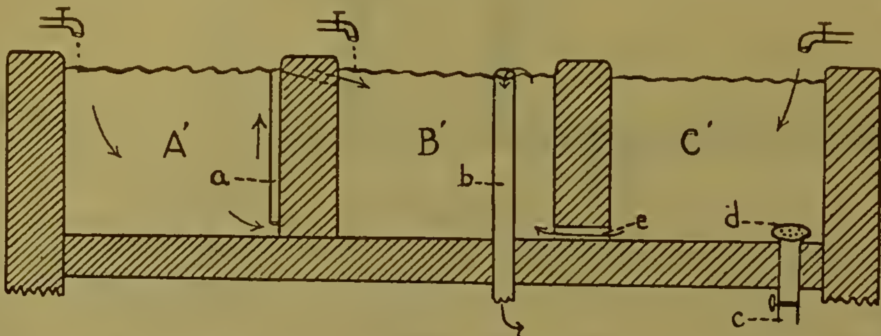


FIG. 31.—Plans of large concrete exhibition aquaria, Millport biological station. Longitudinal section through tanks *A′ B′ C′*, showing circulation and siphon (*a*), standpipe (*b*) for outflow, washout (*c*), with strainer (*d*) and bottom connection (*e*) between *C′* and *B′*.

were made after plans by Prof. James F. Gemmill, of Glasgow University, who supervised their construction during the modeling process, on a special order for the station at a local pottery. They are not to be found in the trade. The material is ordinary fire clay with a clear white glaze. The dimensions used are the following, outside measurement, in inches:

Dimensions of aquaria, in inches.

Kind.	Width.	Length.	Depth.	Thickness of wall.
Sorting tank (*A*, fig. 29; fig. 32)	24	36	8.0	1.5
Experimental aquaria (*B*, fig. 29; figs. 34 and 35)	21	30	15.0	1.5
Exhibition aquaria, small (*C*, fig. 29)	24	35	10.0	1.5
Exhibition aquaria, large (*D*, fig. 29; fig. 34)	22	45	16.0	2.0
Glass-faced aquaria (*E*, fig. 29; fig. 33)	15	45	13.5	1.5–3.0

The accompanying figures (figs. 32 to 36) give the details of construction in a diagrammatic fashion, and general views will be seen in Plate XXXVII.

In use the aquaria are arranged in banks, each tank being set 1.5 inches lower than its neighbor to one side, and the water in circulation passes from one tank to the next lower one through spillways, or if desired each tank can have its own independent circulation, receiving its supply from the tap above and discharging either from the surface through a fire-clay column (*G*, fig. 36) into the waste pipe below, or through a perforated fire-clay stopper (*B*, fig. 36, and *e*, fig. 35) in

A. AQUARIA IN EXHIBITION ROOM.

B. AQUARIA IN RESEARCH ROOM.

FIRE-CLAY AQUARIA AT MILLPORT

the side wall into the cement waste way between the two rows of tanks. The water enters the aquaria in most cases through a shaft formed by a fold (*a*, figs. 34 and 35) in the fire clay at the end of the tank and spreads out over the bottom, and the waste water is drawn off at the top. The spillways from one tank to the next are formed

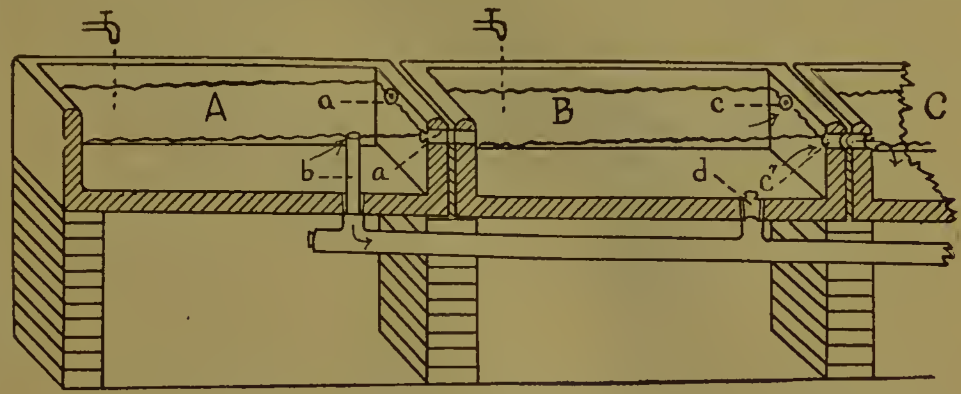


FIG. 32.—Aquaria, Millport biological station. Longitudinal section of interconnecting single series of fire-clay sink-aquaria (*A*, fig. 29). *A*, *B*, *C*, tanks in series; tank *A* arranged for independent circulation, with connecting outlets at *a* closed with solid stoppers (*C*, fig. 36) and drained by vertical standpipe (glass) at *b*, into lead waste pipe below. Tanks *B* and *C* with connected circulation through perforated plugs (*B*, fig. 36) at *c* and *ć*, washout closed (*F*, fig. 36).

either by a tunnel (*C*, fig. 34) closed by a perforated fire-clay plug (*B*, fig. 36) or by a channel closed by a perforated shield (*A*, fig. 36) held in place in a slot (tanks *B* and *C*, *h*, figs. 34 and 35). The flow of water can also be checked by perforated plates (*D*, fig. 36) set in the base of the vertical shafts (*a*, figs. 34 and 35).

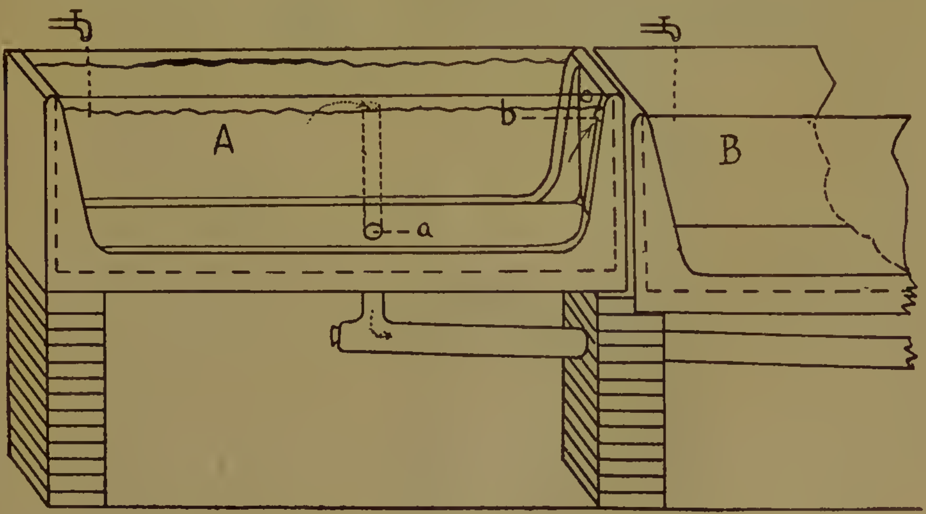


FIG. 33.—Aquaria, Millport biological station. Fire-clay aquaria with glass sides (*E*, fig. 29, and upper aquaria, Pl. XXXVII, *B*). Dotted lines show position of plate glass.

The advantages of aquaria or culture basins of this material are a smooth, noncorrosive surface, easily cleaned, entire absence of all metals, and for purposes of sorting and exhibition, a clear white background, though a considerable range in colors may be had if desired. To these advantages are to be added great durability,

small risk of breakage, ease of combination with cement in construction, and great adaptability in form. As Doctor Gemmill writes, "Fire clay is a delightfully plastic material, and within certain limits as to size, support of sides, etc., any form required can be made."

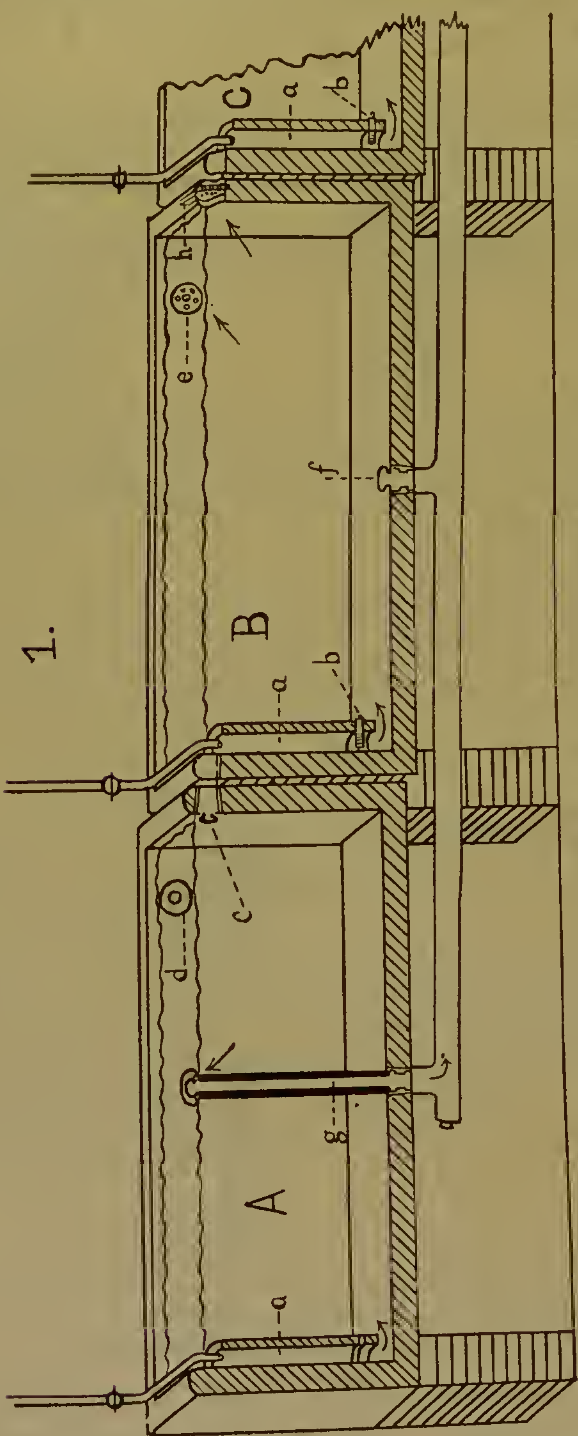


FIG. 34.—Double-bank fire-clay aquaria at Millport station (*B* and *D*, fig. 29; Pl. XXXVII, *B*, and lower aquaria in *A*). Longitudinal section of tanks *A*, *B*, *C*. Tank *A* arranged for independent circulation with orifice at *d* into middle cement channel (see fig. 35) closed with solid plug (*C*, fig. 36), as is also the outlet at *c* into tank *B*. The connection between *A* and *B* is shown as a circular orifice, between *B* and *C* as an open channel with perforated stopper (*A*, fig. 36) at *h*. Outlet from tank *A* goes through vertical fire-clay stand-pipe *g* (*G*, fig. 36) into lead waste pipe below. Outflow from tank *B* passes either through perforated stopper (*B*, fig. 36) at *e* into middle cement channel or through perforated strainer (*A*, fig. 36) at *h* into tank *C*, passing down vertical fire-clay shaft *a* to bottom of tank. The bottom of the shaft is protected by a fire-clay strainer (*D*, fig. 36) at *b*.

In the rear, adjacent to the tank rooms, is the pump room (10 by 10 feet) and the stair leading to the laboratory (fig. 30) (24 by 27 feet) and library (15 by 20 feet) above. The elementary laboratory

has desk room for 35 students, and is abundantly lighted by 18 windows and opaque glass on the northern slope of the roof. The adjacent museum is also lighted in part by skylights. A small research room (10 by 14 feet) and an L-shaped storeroom occupy the space between the class room and the library.

The water supply is drawn through 3-inch lead sea pipe, 200 feet in length, extending to a depth of 8 feet below low tide and terminating in a lead rose held in place in an iron pyramid. A gas engine originally employed in pumping has been replaced by a "Samson" paraffin engine of 4 horsepower. The pump is a specially constructed double-suction pump, with gun-metal plungers and lining. The water is stored in a tank of cast-iron plates protected inside by a coat of tar and outside by red lead, 19 feet 3 inches long, 11 feet 6 inches wide, and 6 feet 3 inches deep. The distributing system is entirely of soft lead piping, with gun-metal valves and brass cocks at the terminals. Some difficulty has been experienced in corrosion of the solder used in setting the cocks in the lead pipe. The water is delivered to the aquaria in overhead sprays and is passed but once through the tank or tanks.

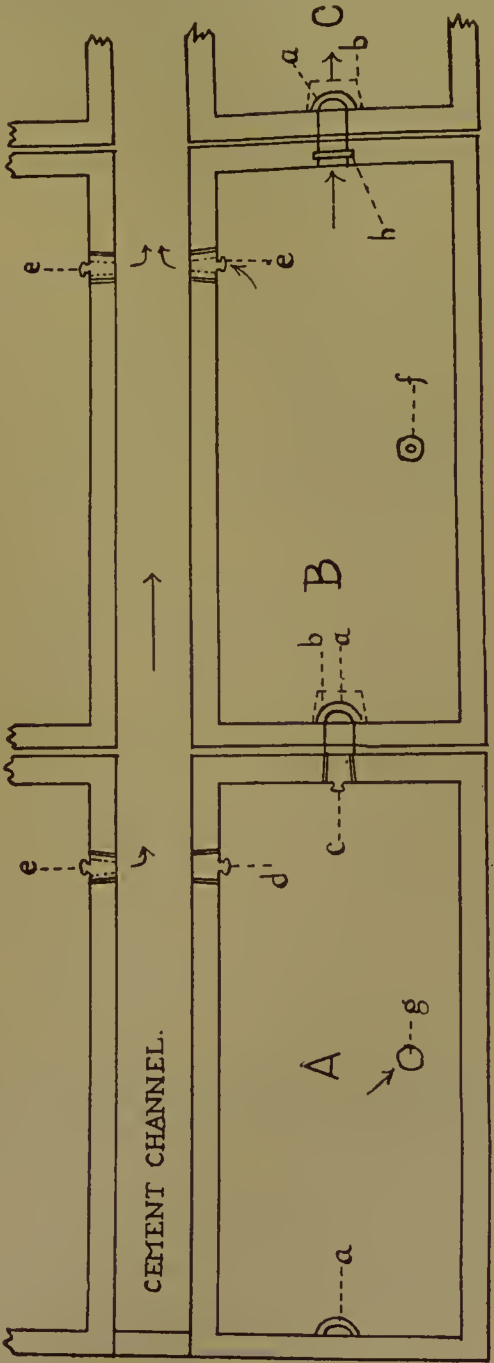


FIG. 35.—Double-bank fire-clay aquaria at Millport station (*B* and *D*, fig. 29; Pl. XXXVII, *B*, and lower aquaria in *A*). View of tanks of fig. 34 from above.

The laboratory has a fair amount of glassware and chemicals, used in biological work, and an exceptionally complete equipment of scientific instruments, including 4 highest grade microscopes of the best makes, with a wide range of accessories; 25 student microscopes and an equal number of dissecting

microscopes; 2 micro-photographic cameras, with well-equipped dark room; 3 microtomes; some chemical apparatus; and a considerable number of pieces of standard physiological apparatus. A full list of the scientific apparatus will be found in the report for 1903.

The marine equipment includes the steam yacht *Mermaid*, 65 feet in length, 13 feet beam, a depth of 7 feet 6 inches, gross tonnage of 35 tons, 80-horsepower compound engine, and a speed of 10 miles per hour. There is a steam winch for handling the anchor chain and the 200 fathoms of phosphor-bronze dredging cable. The cable is

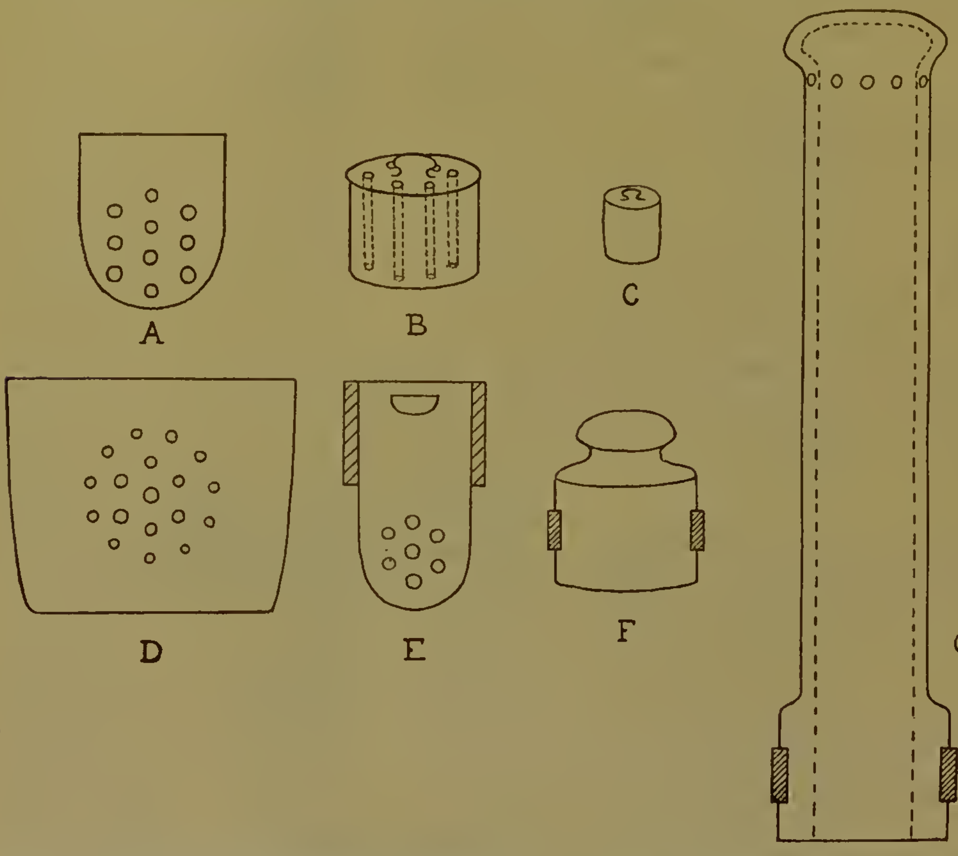


FIG. 36.—Various accessories to aquaria at Millport Station: A. Perforated plate for end channel (*h*, fig. 34). B. Perforated plug for side or end orifices (*c*, fig. 34). C. Solid plug for same (c and *d*, fig. 34). D. Perforated plate for bottom of shaft (*a*, fig. 34). E. Perforated plate for end orifice (*c*, fig. 34). F. Plug with rubber gasket for bottom orifice (*f*, fig. 34). G. Standpipe with rubber gasket, for surface outflow (*g*, fig. 34).

carried out on a dredging boom from the foremast and a large space aft of the mast is left free for landing the dredge or trawl. The steering gear and levers for operating the steam winch are on a platform in front of the funnel, in full view of the forward part of the ship. A small deck house aft is fitted as a laboratory. On the starboard side is a row of ten storage tanks, with provision for salt water circulation from the engine pumps, for use in bringing living material from the collecting grounds to the laboratory. A full description of the ship will be found in Mr. Todd's (1901) handbook of the station.

The station has an ample supply of gear and tackle for collecting purposes, beam, shrimp, and other trawls, tow nets, a Mill thermometer, water bottle, and a current meter.

There is a catalogued library of about 750 volumes and 800 pamphlets, dealing mainly with marine zoology and the local fauna, but containing few sets of periodicals. Lists of additions to the library are published in the annual reports.

The Robertson Museum, with the supplementary material accumulated by the station contains a well-labeled and carefully arranged collection of the local fauna and marine flora, the latter arranged in frames about the walls.

A very full list of the species composing the fauna and flora of the Clyde region and a fine map of the Clyde Basin were published under the editorship of Messrs. Elliot, Laurie, and Murdoch, by the local committee of the British Association for the Advancement of Science in 1901, on the occasion of the meeting of this organization at Glasgow. The lists are accompanied by references to some of the pertinent faunistic literature and give brief notes on frequency and areal distribution. The fauna immediately accessible at Millport is largely represented in these lists.

The rocky shores of the Isle of Cumbræ and the rocky bottom of the Firth of Clyde afford attachment and shelter for an abundant fauna fed by the rich plankton borne in the tidal currents that sweep in and out of this great estuary. The tidal amplitude at spring is considerable (9 feet), leaving exposed at low tide *Fucus* and *Laminaria* zones of considerable extent, affording the best of shore collecting. Hydroids, anemones, echinoderms, worms, crustacea, and mollusks are easily accessible both in considerable variety of species and large numbers of individuals. Much of the shore fauna can also be obtained at any season by dredging in easily accessible localities. Mud and sand flats of limited extent are easily accessible at the head of Millport Harbor. The deepest water in the Clyde area is 107 fathoms and its average depth 29 fathoms. Much of the area near the station is less than 20 fathoms in depth, but depths exceeding 80 fathoms are within 10 miles of Millport.

Fishing for commercial purposes is at present prohibited within the Firth of Clyde. Biological material from this source must needs come from some distance.

Not the least of the advantages possessed by the Millport station is the purity of the water. The distance from Glasgow (35 miles), the width (6 miles) of the Firth of Clyde at Millport, and the great volume of tidal inflow greatly reduce the danger from contamination of the water supply by the sewage of Glasgow. The location of the station beyond the mouth of Millport Harbor and the small population of that port remove the possibility of local contamination. Investi-

gators desiring to conduct experimental work upon living organisms will not only find abundant material close at hand, but also favorable environmental conditions in matters of purity, temperature, and salinity of the sea water.

The range in temperature of the sea water in the Clyde Channel, which is practically homothermic from bottom to surface, is from a winter minimum of 42° to 44° in March to a maximum of 56° in September. The salinities of the channel waters are nearly those of normal sea water, owing to the relatively large tidal influx. The average percentage of pure sea water present in the Loch Long Basin, at the lower end of which Millport lies, is 92.2 per cent. The brackish waters are confined wholly to a thin skin at the surface.

The Millport location offers exceptional advantages for the development of a fine research station. The easy access from Glasgow, the abundant and easily obtained fauna and flora, the purity of the water, and the attractive situation all conduce to this end. The ample equipment of aquaria and the excellent collecting steamer afford unusual advantages to one desiring to conduct observations upon or experiments with living animals. The equipment in instruments and apparatus is also unusually complete. The Millport station deserves to be better known and more widely useful to the cause of marine biology than it has been in the past, and needs a fuller recognition of those possibilities and a scientific rather than a popular basis for its fundamental policy to bring it into the front rank of European stations. Its highest influence in both lines can only be realized with adequate support and a scientific direction sympathetic toward the popular phases of its work.

Literature: Annual Reports, 1896–1908; Todd (1901); Elliot, Laurie, and Murdoch (1901); Hartlaub (1902); Pace (1905, 1908).

GATTY MARINE LABORATORY, ST. ANDREWS, SCOTLAND.

Director, Prof. W. C. M'Intosh, professor of natural history in the University of St. Andrews. Address: Nevay Park, Meigle, Scotland.

Keeper, A. W. Brown.

The location of the University of St. Andrews near the seashore early invited the establishment of a marine biological station at this ancient seat of Scottish learning. The project was advocated by the present director in a public address in 1875, and again in 1882. The H. M. Trawling Expedition of 1883–84 gave additional impetus to the movement. At last the Government, mainly at the instigation of the Earl of Dalhousie, granted a small subsidy through the Fisheries Board for Scotland for the equipment and upkeep of a biological station. A temporary wooden building, formerly used as a fever hospital, on the East Bents, projecting into the waters of St. Andrews Bay, was leased and fitted for laboratory purposes. A

gas engine and a vulcanite pump were installed to supply the aquaria, and the station was formally opened for work in January, 1884, under the direction of Prof. W. C. M'Intosh of the university. A slender subsidy of from £70 to £150 per annum from the Scottish fisheries board sufficed to keep the institution in operation till 1896. Over 150 articles or monographs were published in the interval between 1884 and 1896, when the subsidy was withdrawn. These writings deal with the local fauna or with the structure, development, and œcology of the fishes and invertebrates, mainly those of economic value, a record unsurpassed in scope and significance upon such a slender income. The greatest service this station has rendered has been the establishment of scientific fisheries work and the training in marine biology, which equipped a number of young men for service in the fishery bureaus of Great Britain and her colonies, viz, Prince, Holt, Masterman, Fullarton, Wallace, Kyle, and others.

A gift of £2,500 from Dr. Charles Henry Gatty, himself a naturalist and zoologist, made it possible for the university to erect a new and adequate building for the station. The building was begun in 1894 and formally dedicated to its uses in October, 1896. It still continues under the direction of its founder, Professor M'Intosh, but is no longer affiliated with the fisheries bureau.

The director of the station is professor of natural history in the university, and the station is an integral part of that institution, which pays the salary of the attendant and the cost of repairs and upkeep.

No regular courses are given at the station, though Saturday demonstrations are held, and the building is open at any time to students who care to avail themselves of the opportunity to work.

The present station is on the shores of St. Andrews Bay, about a mile from the biological laboratories of the university, in the southern suburbs of the city, not far from the fine old ruins of the cathedral. The site of the building is on a line of sand dunes skirting the bay on the margin of the farm of St. Nicholas, belonging to the university. The ample grounds contain 3 to 4 acres, through which a small stream runs, affording excellent collecting grounds for fresh-water material. From the station one has a commanding view of the cathedral and castle to the west, and of the bay and cliffs of the Forfarshire coast to the east.

The building is a handsome structure, the style of which is a simple treatment of the English Renaissance. It is in the form of a long rectangle (36 by 120 feet), with its main axis running north and south and its front to the east. It stands about 12 feet above high tide and immediately upon the sandy strand. It is a one-story building, with spacious attic, slate roof, and walls of stone. The height of the ceiling is 13 feet 6 inches. The arrangement of the rooms is shown

FIG. 37.—Plan of Gatty marine laboratory, St. Andrews.

in figure 37. The following description is drawn in the main from Professor M'Intosh's ('96) account of the station:

The entrance to the Gatty marine laboratory is in the projecting block on the west. The door opens into a vestibule (*A*) (fig. 37), which is shut off from the spacious, well-lighted, and well-ventilated hall (*B*) by glass doors. On the right of the hall is a teak side table, covering a coil of pipes for warmth in winter, while further inward lobbies lead to the right and to the left. The latter are of sufficient breadth to permit the use of wall cases, and they are well lighted from the roof. A double line of picture molding provides for the display of a fine series of colored drawings of the marine animals of the local fauna and the original plates of many publications issued from this station. The whole—that is, the hall and the lobbies—moreover, map out the central block of the laboratory, which contains the director's room (*C*), the library (*D*), and the room for specimens (*E*), the two former looking eastward into the bay, the latter to the west.

The director's room (17 feet 9 inches by 15 feet) is reached by a door near the northern end of the lobby on the left, and is lighted by 3 high windows, along which a table (*t*) runs, with a basin on the right. On the southern wall, over the fireplace, is a bookcase, flanked on the east by a wall press (*w*) and on the west by a glazed cabinet (*c*). The walls to the height of 8 feet are covered with shelves, on which are ranged the working specimens of the eggs, of the food and other fishes, their larval, post-larval, and young stages. This collection embraces the labors of many years and contains many rarities. The size of this room is 17 feet 9 inches by 15 feet and the height 13 feet 6 inches.

The library (17 feet 9 inches by 15 feet) has the same general arrangement as the director's room and is reached by a corresponding door from the right lobby. The large windows look also to the east. The northern wall has a fireplace in the center and a glazed cabinet (*c*) in a recess on each side.

The western side of the central block holds also the specimen room (17 feet 9 inches by 15 feet), which is on the left, opposite the director's room. It is lighted by two spacious windows, the sill of both being occupied by a continuous table suitable for two or more senior workers or groups of students. The rest of the walls are occupied to the height of 8 feet by closely arranged shelves for typical marine collections of various kinds from the lower to the higher. The eastern wall has a glazed cabinet for an interesting series illustrating the pelagic fauna and flora of the bay from January to December.

On the right the western side has two apartments, that adjoining the vestibule being the lavatory (*F*) (8 by 14 feet), and the next a

small chemical room (*G*) (8 by 14 feet) with a sink. In the former is a communication with the spacious attics, and in the latter (*G*) are stored chemicals and other apparatus.

The glass door on the extreme south of the right lobby leads to the research room (*H*) (30 feet 6 inches by 30 feet) and contains compartments (*W*) 10 feet square, with partitions about 8 feet in height for six workers, or more if necessary. Each of these has at the lofty window a large and convenient table (*N*) solidly fixed laterally and supported on a specially rigid floor to prevent vibration. On the left of each table is a sink and water pipe, together with a black and a white plate for special dissections. On the right the wall is occupied by a series of graduated shelves (*P*) for books and preparations, while behind is a cabinet of drawers (*O*) for the storage of delicate specimens and apparatus. A screen closes each compartment, at the option of the worker, and thus secures privacy, while the ventilation, and in winter the warmth, of the whole can be comfortably adjusted.

In the center of the room is a series of small concrete tanks (*I*) for sea water, six in number, and therefore corresponding to the compartments. Each tank is 2 feet wide, 2 feet deep, and 4 feet long, with plate-glass front and granolithic walls 2½ inches in thickness. This arrangement is shown in Plate XXXVIII, *B*. A broad, sloping shelf of concrete beneath permits the use of various smaller vessels, at the discretion of the workers, the waste water being collected in a central channel and flowing away at one end. On the other hand, each of the tanks has its own overflow pipe. The supply of sea water reaches this department by the specially built passage beneath from the engine room to the research room, and along which workmen can readily pass without disturbing the floors. The floor beneath and adjacent to the tanks is of concrete.

The terminal door of the lobby on the left conducts to the tank room (*J*) or aquarium (30 feet 6 inches by 30 feet), lined with smooth bricks throughout. Three windows on each side (east and west) admit light, modified by cathedral glass, and at a comparatively high level. The floor is of concrete, while all the other floors to the south are of wood. Four large tanks of glass and concrete occupy the eastern side, supported on massive walls of concrete, which again rest on a special foundation of at least 3 feet of rough concrete altogether independent of the masonry of the building. The aquaria are 5 feet wide, 7 feet long, and 3 feet deep, with granolithic walls 9 inches thick and plate-glass fronts 1¼ inches thick. The glass was originally held in place at the top by angle iron. This rusted, however, so as to crush the glass and has been replaced by wood. Each tank is supplied with sea water by vulcanite pipes from the high-level tank, and has an overflow pipe of iron enameled with glass.

A. SEEN FROM THE WEST.

B. RESEARCH ROOM, SHOWING CUBICALS AND CENTRAL AQUARIA.

GATTY MARINE LABORATORY AT ST. ANDREWS.

It has been found, however, that rust soon breaks the enameled lining and it falls away.

The walls of the tank room afford space for various instruments and models connected with marine exploration, as well as for illustrations of these and of marine animals.

From the northern end of the tank room a door leads by a few steps to the receiving room (*K*) (10 by 14 feet), a compartment communicating otherwise only with the open air by a door and windows on the western wall. This has a slate table and a large sink at the windows and a series of shelves to the rear. In this compartment the contents of the nets, dredges, trawls, and other collecting vessels are subjected to a preliminary examination and the separate groups distributed to the workers or to the tanks.

The northern end of the building is occupied by the engine room (*L*) (10 by 18 feet) containing a gas engine and pump, from which pipes lead, on the one hand, to the high-level tanks, and, on the other, to the underground tank. Sufficient space exists in this apartment for a bench and tools, and the roof has two strong beams for raising heavy weights. A dark store press is at the western end, and adjoining is the iron-plated door leading to the heating chamber (*M*) (8 by 15 feet), which is reached by an iron ladder. and communicates with the hatchway for coals. The establishment is heated by hot-water pipes from this chamber on the "low-pressure system," though fireplaces occur in three of the central apartments.

The whole of this department is carefully isolated by stone walls or thick partitions of brick from the floor to the roof, so that vapors from the gas engine or heating chamber are prevented from gaining entrance to the rest of the building.

The water was originally drawn from the sea through a vulcanite pipe, but this was so easily damaged by the storms that it has been replaced by a 2½-inch iron sea pipe, galvanized after fitting, carried 600 feet to sea to low-water level on the beach. The pump is operated by a 5-horsepower Crossley gas engine, using illuminating gas for fuel. The water is pumped under favorable conditions of tide and weather into a large underground concrete tank, whence it can be pumped as needed into the high-level concrete tank over the engine room. The pipes of the circulating system are of vulcanite or lead, with brass cut-off valves and vulcanite cocks at the terminals. The vulcanite pump has been replaced by a brass pump. If desired, the water from the aquaria may be returned to the low-level storage tanks.

A workshop and dark room for photographic work are installed in a detached wooden building (12 by 20 feet).

The station possesses a 20-foot yawl, the *Dalhousie*, a small boat, and a supply of trawls, dredges, tow nets, and implements for shore

collecting. The usual lines of laboratory glassware and reagents, paraffin bath, microtome, and microphotographic apparatus will also be found here. No provision is made for hydrographic work. The library contains a set of the *Challenger* reports, a generous selection of works pertaining to the fisheries, and several hundred volumes, including numerous pamphlets on the fauna. The Gatty library of rare works on marine algæ and the Gatty herbarium is also found at the station. The library of the university is at the service of investigators at the station.

A concise account of the local fauna has been published by Professor M'Intosh (1875) as a separate memoir.

The investigations carried on in this laboratory have appeared in various scientific journals, principally in the Annals and Magazine of Natural History, where the director has published from time to time "Notes from the Gatty Marine Laboratory," in the Reports of the Scottish Fisheries Board, where the work of economic significance has appeared, and in various scientific periodicals. A full list of these titles, numbering 225 up to 1896, is found in Professor M'Intosh's (1896) account of the laboratory.

Literature: Prince (1889), M'Intosh (1882, 1888, 1895. 1896), Dean (1894), Hartlaub (1902), Sand (1897).

FISHERIES BOARD FOR SCOTLAND.

MARINE LABORATORY AND FISH HATCHERY AT BAY OF NIGG, ABERDEEN.

Scientific superintendent, Dr. T. Weymss Fulton, 417 Great Western Road, Aberdeen.

Assistant, Dr. H. C. Williamson, Marine Laboratory, Bay of Nigg, Aberdeen.

In addition, one attendant for laboratory and hatchery.

This board has had marine stations at Tarbert, Lochfyne, Rothesay, Dunbar, St. Andrews, and Aberdeen. The only one now in existence is that at Aberdeen, which was built some ten years ago, the hatchery being at the same time removed from Dunbar and reerected alongside. The direction of the scientific work was early put under a scientific committee of the board and later under a superintendent of scientific investigations. Prof. Cossar Ewart was convener of the committee, and Dr. T. W. Fulton was appointed superintendent in 1890, and has continued to hold that office since. Among members of the staff may be named Mr. George Brook, Dr. John Beard, Dr. J. H. Fullarton, Dr. Thomas Scott, Mr. W. L. Calderwood, Mr. J. Duncan Matthews, Mr. H. C. Dannevig, and Mr. F. G. Pearcey. Special researches were also undertaken from time to time by various gentlemen, including Professors Brady, Cleve, T. H. Milroy, E. E. Prince, Stirling, Greenfield, and Sims Woodhead, and Drs. Francis Day, H. N. Dickson, H. R. Mill, H. M. Kyle, A. T. Masterman, W. Ramsay Smith, W. Wallace, and

others. Prof. W. C. M'Intosh made a large number of well-known researches at the laboratory at St. Andrews.

When the international fishery investigations were instituted the vote for scientific investigations was reduced from £2,770 to £770, involving reduction in staff, etc.

The plant at the Bay of Nigg consists of the laboratory, aquarium and tank house, a tidal spawning pond, concrete high-level reservoir, hatching house, boiler and pump house, and a storage house, in grounds containing 28,000 square feet.

The laboratory (28 by 58 feet) is a one-story brick structure containing an office and two laboratory rooms used by the staff of the station.

The aquarium or tank house (27 by 46 feet) is a rough wooden structure of one story, partially built over one end of the spawning pond, with platform over the water. It contains six large aquaria—four with plate-glass front and back and the other two with plate-glass fronts only. The former are 6 feet 4 inches long, 4 feet 3 inches wide, and 3 feet 6 inches high. The latter have the same dimensions, except that the length is 5 feet 4 inches. The walls and bottom are of concrete, 6 and 9 inches thick. The upper edge of the glass rests against an angle iron bar with wooden face. The center of each plate glass has been supported by a vertical iron brace with wooden face, which passes down from the angle iron across the front of the glass. Plate glass of a thickness of 16 mm. is used.

The tanks have both salt and fresh water supply. A laboratory table, with top sloping to a central leaden gutter and overhead water supply, runs along one side of the room.

The spawning pond is a rectangular concrete basin (35 by 90 feet), sunk in the ground below tide level, with sloping bottom, giving depths when filled of 8 to 10 feet. It holds 160,000 gallons of water. Water is admitted to the pond from the beach by a 12-inch inflow pipe, partly of iron and partly of fire clay, which terminates at low-tide level on the beach in an upturned iron section, rising to a height of 2 feet above the bottom and covered with a shield of wire netting to keep out sea weed and débris. The outflowing water escapes, as the tide falls, through a flap valve at the end of the line below the intake. The water on entering the pond is received, first, into a compartment called the filter chamber, where it passes through wire netting or other filters. Side valves control the connection between this chamber and the sea on the one hand, and the pond on the other.

The reservoir is an elevated concrete basin (20 by 29 feet and 7 feet in height), holding 15,570 gallons. It is filled from the filter chamber and supplies the hatchery and aquarium rooms. The

water for circulation is drawn from the surface by means of a flexible hose connected with a floating box, and is passed through flannel or other filtering material to avoid matter in suspension.

The hatching house (24 by 49 feet 6 inches) is a one-story wooden building, well lighted, with cement floor, having convenient gutters to carry off the waste water. The hatchery contains an equipment of twenty-two Dannevig hatching boxes, with tip buckets sunk in pits below the floor, operated by the waste water from the hatching trough. The water passing through the hatchery is filtered through flannel or blankets as it comes from the reservoir. The filters are wooden boxes (4 by 8 feet and 2 feet deep), into which fit frames made tight with rubber bands. The frames are covered with wire netting over flannel, up through which the water is forced by pressure from the reservoir. A sewer outlet from the city of Aberdeen, discharging not far from the bay of Nigg, has caused serious trouble in the hatchery recently.

The pump house (18 feet 10 inches by 15 feet) contains three Worthington direct acting, brass-lined, steam pumps, and boiler. The pumps are capable of filling the reservoir in two and one-half hours, drawing the water from the filter compartment of the spawning pond. The distributing and circulating system is of thoroughly galvanized-iron pipe with cocks and valves of brass. It has given good satisfaction.

The work of the scientific department of the fishery board for Scotland is published annually in Part III of the "Annual Report" of the board, the twenty-sixth issue appearing in 1908. It covers a wide range of subjects pertaining to the fresh water and marine fisheries of Scottish waters, including much upon the œcology, development, and growth of food fishes, their parasites, and upon the fauna and flora of fishing grounds, especially the Crustacea.

The station at Nigg Bay has but limited facilities for others than members of the staff of the board, but visiting biologists will find there an extensive collection of British Crustacea and fishes of economic importance and of plankton from Scottish waters. Requests for laboratory facilities will be granted for special work when possible on application to the director.

During hatchery operations in the spring demonstrations and instruction relating to the life histories and habits of food fishes are given to fishermen at the laboratory. Delegates to these conferences are appointed by the technical committees of the counties.

Literature: Annual reports and Fulton (1894, 1906).

SCOTTISH DEPARTMENT OF THE INTERNATIONAL COUNCIL FOR THE INVESTIGATION OF THE SEA.

Main office, fishery board for Scotland, George street, Edinburgh. Telegraph address, Fisheries, Edinburgh. Director's office, University College, Dundee.

Staff: Prof. D'Arcy Wentworth Thompson, Dundee, director; Dr. T. W. Fulton, 417 Great Western Road, Aberdeen; Dr. A. Bowman, 408 King street, Aberdeen; Dr. Thomas Scott, Scottish fishery board's laboratory, Bay of Nigg, Aberdeen (plankton; Crustacea;) Robert M. Clark, 27 Rubislaw Den South, Aberdeen (phytoplankton, etc.); Frank G. Young, University College, Dundee (hydrography); George H. Smith, steamship *Goldseeker*, Aberdeen; Miss Petra Gullaksen, 9 Stanley street, Aberdeen (fish-eggs and larvæ).

The lines of investigation carried on by the Scottish bureau are as follows: (1) Quarterly hydrographic, and plankton investigations at stations between 56° north latitude and 62° north latitude, and from the Faroes to the coast of Norway; similar, but more frequent, observations between the east coast of Scotland and the middle of the North Sea; (2) trawling experiments with commercial otter-trawls and small-mesh nets off the coast of Scotland and in the northern parts of the North Sea; (3) statistical inquiries in regard to the season and place of capture of fish landed by trawlers and liners in Scottish ports and especially in the port of Aberdeen.

The results of the work have been published in Parliamentary Blue Books, code Nos. 2612 (1905), 3358 (1907), and 4350 (1908).

The shore work of the department is distributed between the laboratories of University College, Dundee (hydrography and statistics), the Scottish fishery board's laboratory, Bay of Nigg, Aberdeen. and a small temporary laboratory in Mearns street, Aberdeen.

The vessel engaged in the explorations is the leased steam trawler *Goldseeker*. She has a length of 118 feet, beam of 21 feet 8 inches, draft 8 feet forward, 12 feet aft. She has twin screws, with engines of 290 indicated horsepower, steam winch carrying two lengths of 250 fathoms galvanized-steel dredging cables 2.75 inches in circumference and two of 750 fathoms, 0.5 in circumference. She carries a crew of thirteen officers and seamen, and has cabin space for three to five men in the scientific staff. Her laboratory (9 feet 6 inches by 8 feet 8 inches) is located amidships and is equipped with two tables, racks, and desk.

The biological equipment consists of a full complement of commercial otter and beam trawls, and includes also dredges, plankton nets, with closing nets of Nansen and Garstang pattern, Pettersson-Nansen, Ekman reversing, and Knudsen water bottles and thermometers for hydrographic work.

CHALLENGER OFFICE, EDINBURGH.

Director, Sir John Murray, K. C. B., F. R. S., etc.
Secretary, Mr. James Chumley.
Chemist, Dr. W. A. Caspari, D. Sc.
Assistants, Miss Drummond, M. A., B. Sc., and Miss Stewart.
Telegraph address: Challenger, Edinburgh.

The Challenger office was founded in 1877 to publish the results of the *Challenger* expedition, and since that work was completed it has been continued by Sir John Murray to carry on studies and investigations relating to the science of oceanography.

The office includes a large library, a good chemical laboratory, and other workrooms, and a large collection of deep-sea deposits, etc.

SURVEY OF SCOTTISH LAKES (PULLAR TRUST), EDINBURGH.

Directors, Sir John Murray, K. C. B., F. R. S., etc., and Mr. Lawrence Pullar, F. R. S. E.
Secretary, Mr. James Chumley.
Assistants, Miss Drummond, M. A., B. Sc., and Miss Stewart.
Telegraph address: Challenger, Edinburgh.

The lake survey was founded in 1902 to carry on the bathymetrical survey of the fresh-water lochs of Scotland commenced by Sir John Murray and the late Mr. F. P. Pullar. The field work is now completed, and the actual descriptions and maps of all the lochs surveyed (562 in number) have been published by the Royal Geographical Society. A concluding volume of papers giving the general results of the work was published in 1910.

The laboratory is of special interest because of the perfection here of special instruments for the study of the physical constants and variables in lake waters. Here are found the Pullar sounding machine (see Murray and Pullar, 1900) and the Chrystal recording limnograph, a self-registering statolimnograph, the index limnograph, a modified Sarasin limnograph, and the Murray portable lever self-recording, and vertical-band self-recording limnographs for the study of seiches. A full description of these instruments will be found in a paper by Chrystal (1906).

No permanent fresh-water station has been developed in connection with this survey. The results of the survey, physical and biological, have appeared in the Proceedings and Transactions of the Royal Society of Edinburgh.

SCOTTISH OCEANOGRAPHICAL LABORATORY, EDINBURGH, SCOTLAND.

Director, W. S. Bruce.

The collections and scientific equipment as well as the office and laboratory of the Scottish Antartic Expedition are housed in a one-story building with basement storerooms near Surgeons Hall. The collections of Antarctic life are on exhibition and a fine exhibit of instruments for oceanographical research is also displayed.

BANGOR MARINE STATION, LORNE HARBOR, BANGOR, COUNTY DOWN, IRELAND.

Director, Prof. Gregg Wilson, professor of natural history and geology, Queens College, Belfast, Ireland.
Resident naturalist, W. H. Galloway, Belgravia, County Down.

In 1903 Prof. Gregg Wilson organized at Belfast an "Ulster Fisheries and Biology Association," consisting of a group of naturalists and business men interested in biology. The fisheries industry was not largely represented, as Belfast is not a great fishing port. The purpose of the association was to encourage the study of marine biology, develop a biological station, and render service to the fisheries.

Accordingly, a location was selected at Lorne Harbor, Bangor, on the south side of Belfast Lough, 14 miles northeast of the city of Belfast and connected with it by a frequent service of local trains. A building formerly used as a bath house, located on the water front, was fitted as a laboratory and used as such during the summer of that year.

The laboratory building is a one-story wooden structure containing one large general laboratory room and three smaller ones serving as office and storerooms.

Accommodations for six workers are provided. The building is immediately over the water and has no provision of pump, tank, or aquaria for salt-water circulation. The government department of agriculture and fisheries supplied an equipment of thermometers and tow nets and to these were added dredges and an otter trawl. The station has a 25-foot steam launch for towing and dredging. A working library, including a set of the *Challenger* Reports and those of the Ray Society, together with a number of the monographs on the marine fauna was gotten together.

The station is kept open throughout the year by a resident naturalist, though the active season is from June to September. Properly qualified students are admitted on application to the director, without charges other than those for cost of materials used. Microscopes are not furnished. No courses of instruction are offered.

The investigations at the station pertain mainly to subjects allied to the fisheries, and have been published in the reports of the fisheries board for Ireland. They have been reissued in conjunction with some original contributions in a series called "Scientific Papers of the Ulster Fisheries and Biology Association."

The station is located within easy access of rocky coasts, sand and mud flats, and oyster beds. The tidal amplitude is large, affording a good range of shore collecting.

IRISH FISHERIES INVESTIGATION.

Fisheries branch, department of agriculture and technical instruction, 3 Kildare place, Dublin, Ireland.

Chief inspector of fisheries, W. S. Green.

Inspector of fisheries and scientific adviser, Dr. E. W. L. Holt.

Inspector of fisheries, M. P. Dowling.

Junior inspectors, C. Green and G. P. Farran.

Assistant naturalists, W. M. Tattersall and S. W. Kemp.

Technical assistant, A. B. E. Hillas.

A staff of twelve subordinates.

The fisheries investigations in Ireland are organized under and administered by the department of agriculture and technical instruction. Administrative, legislative, and judicial duties, as well as scientific, are in the hands of this branch and are often performed by the same officers.

The fisheries branch has no direct relation to any educational institution and provides no facilities for elementary or advanced scientific instruction. There is no biological instruction of fishermen in Ireland. Instruction in net mending is given at certain places, and on the institution of new methods of fishing, skilled fishermen are provided by the department or by the congested districts board, of which the chief inspector is a member, to instruct the novices at sea.

The publications, apart from occasional leaflets on fish curing and such things, consist of the "Annual Reports on the Sea and Inland Fisheries of Ireland," which are statutory reports presented to Parliament in continuation of similar reports by H. M. inspectors of Irish fisheries. Since 1900 these reports have been divided into Part I, General Report, and Part II, Scientific Investigations. The latter is a reprint, with a formal covering report by the scientific adviser, of separate papers published under title of "Scientific Investigations."

The scientific investigations of the Irish bureau are directed toward the natural history of the Salmonidæ, their spawning, artificial propagation, feeding and migrations and statistics of their fisheries. In the marine area the work is largely of an exploratory character dealing with the food and other fishes and the local fauna and flora and the bottom deposits. An extensive series of faunistic papers has been issued dealing mainly with the various groups of crustaceans, mollusks, medusæ, fishes, and the plankton of Irish waters.

Collections and specimens are not sold, but are given in great number to museums and universities and practically to any qualified person who asks for them. In return specimens are asked for when required and a good deal of assistance is received from specialists in naming certain items of the biological collections of the bureau.

The *Helga* is practically the laboratory of the bureau, and the field of operations is the coast of Ireland from the shore to 1,000 fathoms.

Ireland was not invited to take any part in the preliminary conferences nor to participate in the work of the International Commission for the Investigation of the Sea, but as the Irish fisheries branch had already commenced observations on practically similar lines it was thought best to synchronize its quarterly cruises with those of the other nations, with whom an informal exchange of results was arranged. Afterwards the Irish organization was asked to enter into more formal relations in that Doctor Holt was invited to attend the meetings of the council and was made a member of several committees, but no financial relations to the larger organization have arisen.

The quarterly physical and plankton observations are communicated to the central bureau at Copenhagen and are set forth in the "Bulletin des Croisières périodiques." Within the last few years the Lancashire and Western Sea fisheries committee and the Marine Biological Association at Plymouth have been able to join hands with the Irish bureau, so that the area of quarterly physical and plankton observations is now continuous from the Norwegian seas through the North Sea and English Channel and thence into the Irish Sea and westward to our 500-fathom line.

Marine scientific investigations are chiefly carried out by the cruiser *Helga*, whose primary duty is the enforcement of fisheries regulations, and it is not possible to say exactly how much of her time is devoted to police work and how much to investigation. Often the two are in progress at the same time. The material collected by the *Helga* is worked out in the office of the bureau, which is merely an ordinary government office with a few simple laboratory fittings in some of the rooms and a fairly good library relating to all the administrative and scientific matters with which it is concerned.

At Ardfry, on Galway Bay, the department has an experimental station for oyster culture, with a few open boats and a permanent staff of three men in addition to the assistant naturalist who generally resides there. This officer makes such local biological and physical study as is necessary in connection with oyster culture, and also helps with the material collected by the *Helga*.

In 1900 the fisheries branch took over from the Royal Dublin Society an old hulk which had been fitted up as a marine laboratory. She was stationed at various places on the Connemara coast until 1904, when she was brought to Ardfry, where she was used as a store until sold for breaking up in 1907.

If any qualified person wished to make a special study of the shallow-water fauna at Ardfry, he would be provided with accommodations for the purpose, but the work of the bureau is the study of biological and physical questions affecting the fisheries, and its installations are designed and from time to time modified ad hoc and not for the general pursuit of pure sciences.

At Valencia, an island at the extreme southwest of Ireland, the Misses Delap have for many years carried on valuable investigations on the plankton and have been most successful in rearing hydroids and medusæ in confinement. Their laboratory, supplied with apparatus from the fisheries bureau, is at their house, Reenellen. Occasionally, naturalists from England have set up temporary laboratories there.

The *Helga* is a fine new steel fishery cruiser, specially built for the work of policing the fishing grounds and for scientific investigation. She is 155 feet long, has a beam of 24.5 feet molded, a depth of 13.5 feet, molded amidships, and a mean draft of 11.5 feet. Her gross tonnage is 322.89 and net registered tonnage 111.49. She is built for speed and rough weather and has twin triple expansion engines of 1,000 horsepower. There is ample deck room aft where the trawling winch and sounding machine are located. A laboratory salon forward (12 by 15 feet) is provided with tables, drawers, sink, workbench and swing table, and large windows. The *Helga* is very completely equipped with the latest instruments of the International Commission for hydrographic, oceanographic, and biological explorations and with tackle and gear for fisheries investigations. A full description of the vessel will be found in a paper by Green (1909).

Literature.—Annual Reports, Green (1902, 1909).

CHAPTER V.

GERMANY.

INTRODUCTION.

The development of the biological stations of Germany has been profoundly influenced by two factors, the existence of the marine station at Naples of German origin and with German subvention, and the development, especially in more recent years, of the nation's commercial and scientific interest in the fisheries. The Naples station, with its rich fauna, fine library, and superb history, is the Mecca that draws to its doors the devotees, young and old alike, of biological science from German universities. This has deferred the development of another station for pure research in the less productive German waters. Aside from the small fresh water station at Plön, all German biological stations are organized directly with partial or complete reference to the economic interests of marine or fresh-water fisheries. They are all none the less engaged in research work of high order and are usually connected directly or indirectly with scientific or technical instruetion. The venerable institution at Kiel (1871) has always been a leader in marine exploration as related to the fundamental problems of marine biology and the fisheries, and a similar motive laid the foundation for the Helgoland station (1892). These two organizations are united with the German Fisheries Society in work of the International Commission for the Investigation of the Sea (1902) in a maze of organization utterly baffling to the foreigner and only equaled by the complexities of the Jahresberichte, Beriehte, Folgen, Bände, Abtheilungen, and Hefte in their publications.

The rise of industrialism and the growth of cities in modern Germany have given rise to questions of stream pollution and water supply which have afforded the motive for the establishment of the fisheries experiment station at Munich (1897) and the magnificent new Institut für Binnenfischerei at Friedriehshagen near Berlin (1908), which superseded the earlier Müggelsee fisheries station (1893), and have lent interest and support to the investigations upon the Rhine and the Elbe (1899). The exploration of fresh waters and the study of fish diseases and of the biology of fishes have entered more or less into the programme of these fresh-water stations. The development of a scientific basis for fish culture is the main function of the pond culture station at Trachenberg (1895 and 1905) and the newly opened one at Wahrenholz. The station at Plön (1890), a pioneer in its field, is mainly eoncerned at present with the faunistic exploration of fresh waters and elementary biological instruction for teachers in the public schools.

GERMAN SCIENTIFIC COMMISSION FOR THE INVESTIGATION OF THE SEA.

President, K. Kais. Geheim. Legationsrat F. Rose, Deutscher See-Fischerei Verein, Berlin, Deutschland.

Members, Profs. K. Brandt (Kiel), F. Heincke (Helgoland), H. Henking (Berlin), O. Krümmel (Kiel).

At Kiel: Kgl. Preussische Kommission zur wissenschaftlichen Untersuchung der deutschen Meere.

Hydrographic division—
- Director, Prof. Dr. O. Krümmel.
- I. Assistant, Dr. E. Ruppin.
- II. Assistant, Doctor Gutschlag.

Biological division—
- Director, Prof. Dr. K. Brandt.
- In charge of quarterly cruises, Prof. Dr. C. Apstein.
- Zoologist, Dr. J. Reibisch.
- Chemists, Dr. E. Raben, Doctor Kraefft, Doctor Merkle.

At Helgoland: Kgl. Preussische Biologische Anstalt
- Director, Prof. Dr. F. Heincke.
- Custodian of fisheries division, Prof. Dr. E. Ehrenbaum.
- Hydrographer, Dr. A. Reichard.
- Biologist, Dr. O. Franz.
- Planktologist, Dr. W. Mielck.

At Berlin: Deutscher See-Fisherei Verein.
- President, K. Kais. Geheim. Legationsrat F. Rose.
- Director of statistical work, Prof. Dr. H. Henking.
- Statisticians, Dr. E. Fischer, Dr. Freiherr v. Reitzenstein.

The scientific work of the German section of the International Commission for the Investigation of the Sea, organized in 1902, is carried on in the main in the preexisting laboratories and by additions to the staffs and equipments of the biological station at Helgoland, and the commission for the scientific investigation of the German Sea at the University of Kiel. The statistical and general administrative work is conducted in connection with offices of the German Sea Fisheries Society at Hannover. (For a detailed account of the Helgoland station see p. 221 and for the Kiel organization see p. 222.)

The principal equipment belonging particularly to the international commission is the research steamer *Poseidon*, built in 1902 at a cost of over 300,000 marks especially for the work of the commission. Her home port is Geestemünde, near Bremen, and her master is Capt. Anton Heinen, an experienced shipping master, familiar with the wiles of the North Sea. She is a steel vessel, schooner rigged, with a length over all of 45.88 m., beam of 9.1 m., draft of 3.5 m., and registered gross tonnage of 482.6 tons. She has two 240-horsepower triple-expansion engines and twin screws. She has a speed of 9 knots per hour, carries 100 tons of coal, and has a steaming radius of twelve days. She has a commodious laboratory forward on the main deck for biological work and a large fisheries laboratory aft, with adjacent fish wells for storage

of live fish. She is equipped with steam winch forward for dredging and trawling, with very heavy commercial otter trawls and other fisheries gear. She has a Le Blanc sounding machine (from the Valdivia expedition) fitted with 1,500 m. of 19 strand galvanized cable of 2 mm. diameter, with breaking strain of 475 kilos. The wire serves both for sounding and for hydrographic instruments such as water buckets and for small plankton nets. The hydrographic and meteorological equipment is very complete, including Richter thermometers for deep-sea work, Assman aspiration thermometers, Pettersson-Nansen and Krümmel water buckets, Fuess barograph, current meters of Nansen and Ekman, transparency disks, anemometers, etc., representing an outlay of about 5,000 marks. A cable 1,500 m. in length is used for anchoring ship in deep water for station work. The fisheries equipment includes the usual commercial nets, otter trawls, and seines and special nets devised for the capture of young fish and eggs in quantity for statistical work. The *Poseidon* has laboratory space and cabins for a staff of thirteen scientific workers and carries eighteen men as officers and crew and four as servants for the scientific staff. Scientific guests wishing permission to visit the ship while engaged in scientific work should apply to the president of the commission.

A Jahresbericht containing an administrative report, accounts of the quarterly and other cruises, and summaries of the investigations in progress is published under the title of "Die Beteiligung Deutschlands an der Internationalen Meeresforschung," I and II (1905), III (1906), IV and V (1908).

LABORATORIUM FÜR INTERNATIONALE MEERESFORSCHUNG, KIEL, GERMANY.

The university at Kiel has long been known to biologists as a center of research in marine biology and oceanography. The "Plankton Expedition" of 1889 was planned and carried out by naturalists from Kiel, and the published results of this great enterprise are largely from men trained at Kiel or associated with its university. It is also at Kiel that the "Kgl. Preuss. Kommission zur wissenschaftlichen Untersuchung der deutschen Meere" has had its headquarters from its foundation in 1870 to the present time. It was established by the ministry of agriculture for the scientific investigation of physical and biological conditions in the Baltic and North seas with special reference to problems of importance to the fisheries. With the establishment of the International Commission for the Investigation of the Sea in 1902 the German commission naturally took part in the work of the German division of this greater enterprise and has from the start exercised a profound influence in shaping the methods and policy of this larger institution.

The University of Kiel, the Kommission zur wiss. Untersuchungen and the Laboratorium für internationale Meeresforschung are three distinct institutions in their organization and administration, but the same men are upon the staffs of the three organizations, and their interests and investigations are closely interrelated.

The "Laboratorium für Internationale Meeresforschung" is located in rented quarters at Karlstrasse 42, in a building ill-adapted to the needs of its work. Here are found the offices of the Prussian Commission, its library, and laboratories for hydrographical, chemical, and biological investigations of the German international bureau. In the same laboratories the students from the university electing work in certain oceanographic or biological subjects receive their instruction in lectures and practical laboratory work.

The hydrographical laboratory is equipped for determination of salinity and dissolved gases in sea water by the Knudsen method or modifications of this method introduced by the chemist, Doctor Ruppin. The chemical laboratory is equipped for accurate analysis of sea water, especially for investigation of the silica and forms of nitrogen in the sea. The biological laboratories of Doctors Apstein, Lohmann, and Reibisch are fitted for the investigation of the plankton and the fisheries, respectively, with especial reference to statistical and quantitative methods. The biological laboratory contains an extensive collection of marine and fresh-water plankton from various parts of the world. The library of the laboratory, containing 2,000 volumes, and of the university is rich in the literature of marine biology and of oceanography. The institute shares with the Helgoland station the use of the *Poseidon* for marine exploration, but has no boat of its own for local work.

The room in the "Laboratorium für Meeresuntersuchungen" is quite limited, and but few investigators or students can be accommodated there. A few properly qualified investigators are, however, admitted. Application should be made to the director for the privilege. This laboratory is primarily a research institution for the staff of the Kiel commission and German section of the international commission. Instruction is given in its laboratories, and students come to it as a matter of convenience to certain members of the university, who are also on the staff of the commission.

The Kiel laboratory is famous in the annals of marine exploration as the center from which sprung the quantitative method of study of marine life known as the Hensen plankton method, after its founder. Many types of apparatus, quantitative plankton nets, closing nets, and other apparatus for use on the high seas, counting apparatus, filters, and centrifuges for laboratory work have been devised in this laboratory by Professors Hensen, Lohmann, and Apstein. Descriptions and price lists may be obtained from the laboratory.

The publications of the Kiel "Commission" have appeared in a series of Jahresberichte (I, II–III, IV–VI, 1871–1876) and Berichte (IV–VI, 1877–1891). With union of publication with the Helgoland station in 1893 a new series, "Wissenschaftliche Meeresuntersuchungen," was established, and in this the results of the international investigations are also published.

Literature: Serials above noted, Kalmmeser (1903).

ROYAL PRUSSIAN BIOLOGICAL STATION OF HELGOLAND.

Director, Prof. Dr. Fr. Heincke, Kgl. Biologische Anstalt, Helgoland, Deutschland, member of the Kiel and the International Commission for the Investigation of the Sea; specialty, biology of food fishes, natural history of herring.

Custodians: Prof. Dr. Cl. Hartlaub, in charge of zoological division, library, North Sea Museum, investigators' tables, and distribution of biological material; specialty, Hydroida and Medusæ. Prof. Dr. E. Ehrenbaum, in charge of fisheries division, aquarium, explorations at sea and marine equipment; specialty, eggs and young of fish. Prof. Dr. P. Kuckuck, in charge of botanical division, of herbarium, and of library exchanges.

Assistant, Dr. W. Mielck, plankton eggs and larvæ of fishes.

Assistants in the International Investigation of the Sea: Dr. A. Reichard, hydrography, the biology of fishes, fish marking experiments, supervision of seismographic station; Dr. V. Franz, biology of fishes; Dr. H. Weigold, plankton.

Technical assistants (twelve): Chief collector, U. F. Lornsen, in charge of collecting excursions, supply of material, tackle and gear, with three fishermen as helpers; chief preparator, John Hinrichs, in charge of shipments, chemicals, stoves, museum preparations, and meteorological station, with an assistant, especially for cruises of the *Poseidon*.

Secretary, Peter Kruss, in charge of correspondence, assistant for herbarium and seismograph.

In addition, a keeper of the aquarium, a chief watchman, and three servants.

Telegraph address: Biologische Anstalt, Helgoland.

The beautiful island of Helgoland has been rendered classic ground for biological work by the investigations prosecuted there by Johannes Müller, Frey, Leuckart, Stein, Haeckel, Claus, and other German biologists, which early led to fruitless efforts to establish a station there. The growth of the Naples station satisfied for the time the need for a seaside laboratory, but upon the cession of Helgoland to Germany by England and its union with Prussia in 1892 the demand for a station on German soil came to a quick fruition. As early as 1888 the the German Society of Coastal and Deep Sea Fisheries put into the field an itinerant zoological station along the North Sea Coast under the direction of Doctor Ehrenbaum, which did much to remove prevalent beliefs as to the barrenness of that region. In 1890 the Emperor became interested in the project and a commission consisting of representatives of the Government, the ministers of the interior and of agriculture, the Prussian Academy of Sciences, the Berlin Aquarium and German Fisheries Society, and Doctor Heincke, was formed to organize and plan the station. In 1892 Doctor Heincke was appointed

director by the Prussian minister of religious, educational, and medical affairs, and its budget assumed by the state. To secure a coordination of its work with that of the previously existing German commission for the Scientific Investigation of the Sea, located at Kiel and controlled by the ministry of agriculture, domains and forests, the director was appointed a member of that commission, and the publications of that organization and the new station united in a new series of the "Wissenschaftliche Meeresuntersuchungen."

A site was purchased and 48,000 marks expended on remodeling the building, formerly a lodging house, and on scientific equipment. The station was opened for work early in December, 1892. Under Doctor Heincke's able direction and the assistance of his unusually permanent staff the station has grown and the scope of its work has been greatly extended. The International Commission for the Scientific Investigation of the Sea was established in 1901, and the Helgoland station shares with the Kiel Institute for Marine Investigation the prosecution of Germany's part of the programme, receiving for this an increase in budget of 13,000 marks annually. The director, Doctor Heincke, the custodian in charge of ichthyological work; Doctor Ehrenbaum, an assistant, and three associates give the greater part of their time to this international work. The German fisheries research steamer *Poseidon*, home port Geestemünde, is used by the Helgoland staff for extensive explorations in the North Sea, the Baltic, and adjacent waters. The demand for room for visiting naturalists and the expanding work of the station have compelled the purchase of four additional houses adjacent to the superb public aquarium opened in 1902. A fine new building is projected to be erected shortly on the site of the present quarters of the station.

The Helgoland station is a royal Prussian organization, responsible directly to the Kultus Ministerium, and its director is appointed by the minister. It receives financial support directly from the state. It is not in an administrative way related to educational institutions. It unites with the sea fisheries bureau and the scientific commission for the investigation of the sea in the programme of the international exploration, and is itself expressly engaged in fisheries investigations, but is not subordinated to either organization. The appointment of the staff and the carrying out of the station's programme is in the hands of the director.

The station receives annually (1908) from the Kultus Ministerium 76,500 marks, of which 13,000 are applied to the work of the international commission. Of the total sum, 42,000 marks are paid for salaries and labor and 34,500 for upkeep. The upkeep of the *Poseidon* is not charged to the station. In addition, about 8,500 marks are received from admissions to the aquarium and 2,500 from sale of

biological material and publications, but this is returned to the treasury of the state.

The programme of the station as drawn up in the state papers establishing it is twofold. In the field of pure science it is obligated—

(1) To provide facilities and material for the investigations of zoologists, physiologists, and botanists, with aquaria for observation and culture;

(2) To provide courses of instruction for young zoologists and botanists and teachers in higher schools on the biology of the sea; and

(3) To supply living and preserved marine material to scientific institutions and museums and to public aquaria. Economic interests, on the other hand, are to be served by—

(1) An investigation of the fishing grounds of the North Sea, the character of the bottom, its animal life and food fishes;

(2) Systematic investigation of artificial culture of food fishes and the lobster;

(3) The determination of the facts governing fisheries legislation;

(4) Monographic investigation of food fishes (herring, eel, haddock, plaice, etc.), with special reference to their development, food, and movements; and

(5) Instruction of practical fishermen in elements of marine biology. In addition to these fields of investigation and work, certain others of more general character were included in the station's programme, as follows:

(1) Investigation of the whole North Sea, and especially the territory adjacent to Helgoland in its physical-chemical, geological, and zoological-botanical aspects;

(2) Regularly continued periodical observations of important phases of marine phenomena (phosphorescence, animal swarms);

(3) Investigation of the plankton as the primitive source of food in the sea;

(4) Geology and land fauna and flora of Helgoland;

(5) Development of a museum of North Sea and Helgoland fauna and flora (including the famous Gaethke bird collection); and

(6) Publication of results.

Substantial progress has been made along most of the lines indicated in this comprehensive programme, except only that of formal instruction of elementary character. The results are published since 1894 in a series of quarto volumes (Abth. Helgoland) of the "Wissenschaftliche Meeresuntersuchungen" in conjunction with those (Abth. Kiel) of the German Commission for the Scientific Investigation of the Sea. In all, eight volumes have been published.

Owing to the considerable number of rooms in the station buildings and the possibility of equipping temporary workrooms with simple

outfits in adjacent private houses, the Helgoland station can accommodate a number of workers in addition to the eight members of the staff. At present ten to twelve places fully equipped are available for outside investigators, thirty-two of whom made use of the station in 1908. The station is open to advanced students and qualified investigators throughout the year.

Application for admission should be made in advance to the "Director der Biologischen Anstalt," Helgoland. A copy of the regulations governing occupants of work tables and a legitimation card granting special rates on local steamers from Hamburg are issued to applicants. The privileges of the station are furnished to all, including foreigners, without charge, except for a nominal library fee of 10 marks. Microscopes and microtomes are furnished only by special arrangement with the director. The equipment of the work tables is ample and includes full supply of the usual reagents and an adequate amount of glassware, with an excellent laboratory desk. Chemicals, breakage, and glassware are charged at cost.

The island is a popular summer resort and living quarters at moderate rates (higher in the season, June–September, and often overcrowded) may be secured near the station in the "Unterland," or above in the "Oberland." Helgoland may be reached daily during the season by steamer (five and one-half to six and one-half hours) from Hamburg and several times weekly by mail steamer at other seasons.

The station supplies living and preserved material for instruction and research at charges proportional to the cost, but issues no list of material to be furnished on demand.

The station is in the "Unterland," on Victoria Strasse, not far from the landing wharf. It occupies a narrow strip of land running northwest by southeast, containing 955 square meters, and fronting upon the sea on the northeast side. It stands about 25 m. from the protected water front and scarcely above water level at times of combined storm and spring tides. It is at present composed of the new aquarium building (Pl. XXXIX) and four frame buildings, formerly dwellings, adjoining, containing 7, 19, 6, and 14 rooms, respectively. The second building contains the office, library, and workrooms of the staff, while the other buildings serve as accessory laboratories and storerooms. In addition to the buildings, the station has elsewhere a large two-story warehouse and workshop and a commodious two-story building, the former "Kurhaus," in which is lodged the North Sea Museum.

The new aquarium building completed in 1902 is a handsome structure of two stories and basement, of rectangular form, with its long axis northwest by southeast, built of reenforced concrete with an exterior finish in pressed brick.

HELGOLAND BIOLOGICAL STATION. AQUARIUM IN THE FOREGROUND WITH FOUR ADJACENT STATION BUILDINGS.

Photograph from Doctor Ehrenbaum.

This building has been so thoroughly planned and so carefully constructed from the architectural and engineering standpoint that it merits a full description. Floor plans and cross sections with dimensions are shown in Plate XL, figures 1–8. The building (11.55 by 12.5 m.) consists of two stories, basement, and attic, and has the form of a three-storied basilica with a central nave and two lateral aisles with included corner tower for water tanks. The building is lighted through glass roofs on both nave and aisles. The basement contains the pump and engine room and the room for the lower storage tanks, while on the ground floor are entrance hall and the U-shaped main exhibition room of grotto construction with black walls, lighted through the aquaria, which form two lateral banks and two central rows about the central light well. The overhead light in both cases passes through obliquely placed semiopaque ribbed glass, with muslin curtains for additional shields. Small windows in the walls also light the attendance corridors of the laterally placed aquaria. The floor above contains three small investigators' rooms (with places for four workers) grouped around the central well and opening by sliding windows into it for access to an encircling glass shelf for small glass aquaria used in experimental work. The attic provides storeroom and access to the high-level storage tanks of the tower.

On account of the turbidity of the shallow sea about the island, especially after stormy weather, it has been necessary to filter the water used in the aquaria and to employ a closed system of circulation. The water is used over and over again, passing through sand and gravel filters after each transit through an aquarium. The filter tanks lie below the corridors along the large aquaria. The combined weight of aquaria and filter tanks is carried by the massive walls on either side of the aisles.

The pumping plant is in duplicate, consisting of a 3-horsepower Deutz benzine motor with an Otto motor of 1 horsepower in reserve, and two pumps, one of 4,500 liters hourly capacity. The benzine is stored in a tank outside the building and the room is lighted by electricity. The sea pipe is a 65 mm. galvanized-iron pipe carried 70 m. into the sea to a depth of 1 m. below low water, where it terminates in a suction basket. The water is pumped from the sea into the low-level tanks and thence as needed into the two high-level storage tanks in the tower of a capacity of 18 and 8 cu. m., respectively. Thence it passes through the distributing system of soft-lead piping to the individual aquaria. The overflow from each aquarium is conducted by lead piping to the filter beds at the sides of the aquaria and the filtrate is stored in the two low-level cement tanks of a capacity of 40 cu. m. each. The duplicate system of engines, pumps, and tanks are so connected that any one element may be

shut out of the circuit for repair or cleaning without interference with the aquaria. The pumps may also be connected with the fresh-water storage cistern outside of the building and the high-level fresh-water tank. All pipes are exposed or easily accessible in covered floor channels. The cocks in the system are either of vulcanite or hard lead (an amalgam of lead and nickel), copper, brass, and iron being entirely eliminated. Very few cocks and valves are used in the system. The aquaria are fed by an overhead jet entering a lead tube whose outlet is at the bottom of the aquarium. The force of the jet carries air into the tube and delivers a finely divided spray at the bottom of the aquarium. The aquaria are provided with vertical overflow pipes discharging through the bottom and with bottom plugs for cleaning out. The tanks are of ferroconcrete on the Monier system. The low-level tanks are each 2.5 by 6.7 by 2.1 m. high, with walls 10 cm. in thickness. The first high-level tank had walls originally 6 cm. in thickness, but these were reenforced later to stop leakage. The present thickness is 12 cm. This tank is cylindrical in form with a diameter of 2.8 m. and a height of 4 m. A supplementary high-level tank was later added. This is 1.8 by 3.9 by 2.1 m. in height, with walls 10 cm. thick. A fresh-water tank 1.15 m. high and 1.57 in diameter with walls 5 cm. thick is placed in the attic. The concrete tanks, with the exception noted, have proved to be very satisfactory. It is, however, necessary to keep the concrete entirely free from fiber of any sort and to pack it with extreme care to avoid minute leaks which the salt water is prone to find.

The proportions and distribution of the large aquaria, eleven in number, are shown in Plate XL, figure 3. They are 1.05 m. high and 1.3 m. wide and 0.75, 1, 1.5, 2, and 3.08 in length with cross walls 5 to 6 cm. and around rear walls 7 to 8 cm. thick, and with angle-iron frames on the corners. The glazed openings are 0.75 m. in height and 0.42 (or 0.62), 0.90, and 1.4 m. in length, the large aquaria (3.08) having two panes, 0.90 m. each and glass 23 mm. in thickness. The largest aquarium, located at the central light well, is 2.54 by 1.84 and 1.75 m. high, with walls 12.5 cm. thick. It is glazed on three sides with openings 1.2 by 0.8 and 1.2 by 1.8 and glass 34 mm. thick.

On either side of the central light well is ranged a row of small aquaria, on the one side eight small aquaria 35 cm. high, 35 to 48 cm. wide, and 45 to 73 cm. long, with walls 5 cm. in thickness, set in angle-iron frames. The openings are 25 cm. high and range in length from 36 to 62 cm., with glass 5 to 7 mm. thick. On the other side is a series of glass boxes 35 cm. in height, 25 to 36 cm. wide and 45 to 55 cm. long, with polished-glass fronts and blackened backs, with overhead water supply and constant level siphon outflow. The central light well and the aisles behind the side tanks form passage-

ways used by the caretakers of the aquaria or for overhead observation. Aeration of aquaria is by overhead jet.

The aquarium is planned primarily for exhibition purposes, but at present the second story is used for laboratories. At the level of the sliding windows which open into the central well is a shelf (Pl. XL, fig. 6) of wire glass and angle iron with margins 4 cm. in height, which serves as an aquarium trough. Outflow water from a glass aquarium placed here is siphoned into the trough and passes thence to the filters below. The aquaria are thus conveniently located for observation and are kept in the more constant and lower temperature of the light well.

To protect the building from ground water there is placed beneath it a solid sheet of concrete 70 cm. thick, coated beneath the wearing floor with 3 cm. of waterproof cement. Since the basement and ground floor are below the level of spring flood tides, the basement windows are water-tight and, together with the entrance, can be reenforced by storm protectors. The roof of the light well is of double glass to prevent condensation of moisture and to regulate the temperature. A small central heating plant and special ventilating arrangements further facilitate the control of temperature conditions.

The aquarium is opened during the summer season for five months only. In 1908 over 16,000 paid admissions were received. The aquaria contain carefully selected and well-maintained groups of the local marine fauna and flora, exhibiting the food fishes and invertebrates, characteristic faunistic assemblages, such as *Zostera* beds, rock fauna, sand fauna, and a number of types selected to demonstrate the range and variety of marine life. It is an educational rather than an exhibition aquarium.

The initial cost of the building and aquaria was about 62,600 marks and of the machines and circulating system 19,400 marks, a total of 82,000 marks. The building itself cost about 41.3 marks per cubic meter. The high cost is attributable in part to the excessive expense of landing heavy materials at Helgoland, where no large boat can come to the wharf, and in part to the difficulties attending the site of the building, the limited area available, and to the permanency and high standard alike of plan and materials used in the structure.

The equipment of the Helgoland station in chemicals and glassware is ample. The instrumental equipment includes twenty microscopes, four microtomes, counting microscope, Stempel pipettes, centrifuge, plankton pump, photographic and microphotographic apparatus, a one-fourth horsepower hot-air motor for an aquarium stirrer, and a full equipment of meteorological and seismographical apparatus.

The equipment for field work, intimately connected with that of the *Poseidon*, includes practically all of the varied types of dredges, trawls, otter trawls, nets, seines, traps, and other gear and tackle used in the commercial fisheries of the North Sea, the most fished body of water on the globe. In addition to this there is a varied supply of young fish trawls and tow nets for the capture of pelagic eggs and fry of fishes, the Petersen young fish trawl, the Scheerbrutz net originating in Helgoland, for towing at desired levels, and a huge collapsing-ring net for active young fish. The materials used in these nets are stramine, Seihtuch (a linen cheese cloth), Eisengarn (a special pattern of horsehair cloth), and the usual bolting-cloth silks. There is also a complete outfit of plankton nets of the Kiel and Nansen patterns. The station is equipped for hydrographic work with Richter deep-sea thermometers, Krümmel water buckets, Nansen and Ekman current meters, and a chemical laboratory for the necessary analyses connected therewith.

The boat equipment consists of several rowboats and sailboats and an open cutter, the *Augusta* (10 by 3 m.), with auxiliary Deutz petrol motor of 12 horsepower.

The library is large, contains 120 complete sets of biological and fisheries journals and 74 partial sets, and receives currently nearly as many periodicals. It contains 9,300 numbers, of which 4,800 are bound. It is rich in the literature of ichthyology and the fisheries, ornithology, and marine botany. Library lists will be found in the first two volumes of the "Meeresuntersuchungen."

The collections are housed in the Nordsee Museum on Kaiserstrasse, in which is placed the superb Gaetke collection of Helgoland birds, including the specimens upon which are based many unusual or rare records. There is also a fisheries exhibit and an excellent representation of the fauna and flora of the North Sea from the systematic standpoint. The biological exhibits illustrating the life history, growth stages, age characters, food, and habits of North Sea fishes and the lobster and typical assemblages of shore and bottom fauna and flora are especially instructive and exhibit a high degree of technical skill and originality. The museum was established by a gift of 25,000 marks from the heirs of Professor Pringsheim, the botanist.

The herbarium of marine algæ at the station is rich in types from northern waters and contains over 4,000 carefully named sheets of material, much of it from eminent specialists or classical localities.

Helgoland is a tiny islet, 1,600 m. long and 600 m. wide, whose banded reddish brown cliffs of Triassic sandstone, 25 to 36 m. high, rise perpendicularly from the sea on all sides save one, where the closely built Unterland rises a few meters above the ever-eroding sea. The Oberland is a green plateau, the favorite resting place of migrant

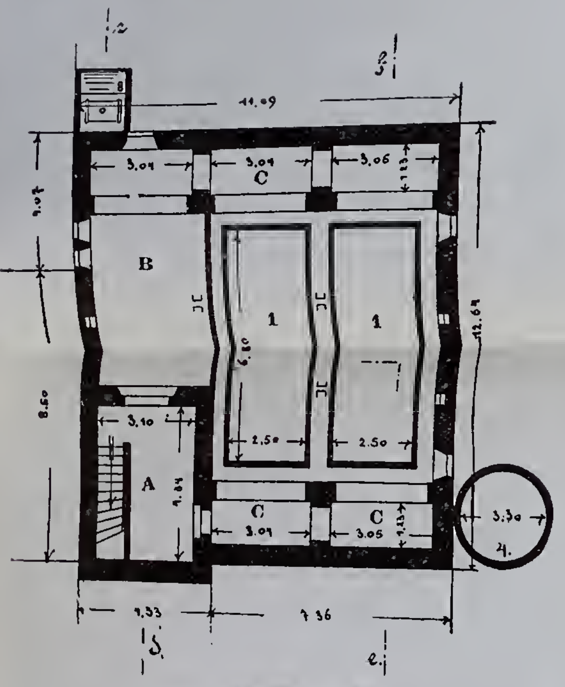


FIG. 1.—BASEMENT FLOOR.

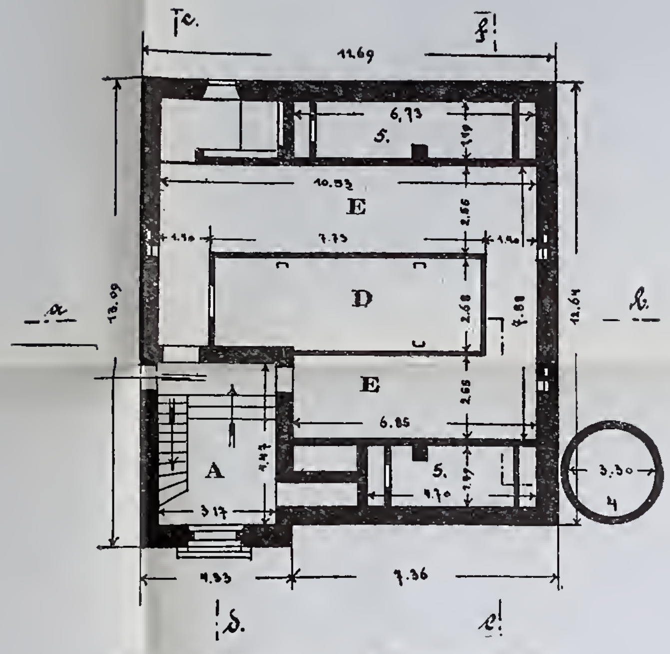


FIG. 2.—GROUND FLOOR, AT LEVEL OF FILTER BEDS.

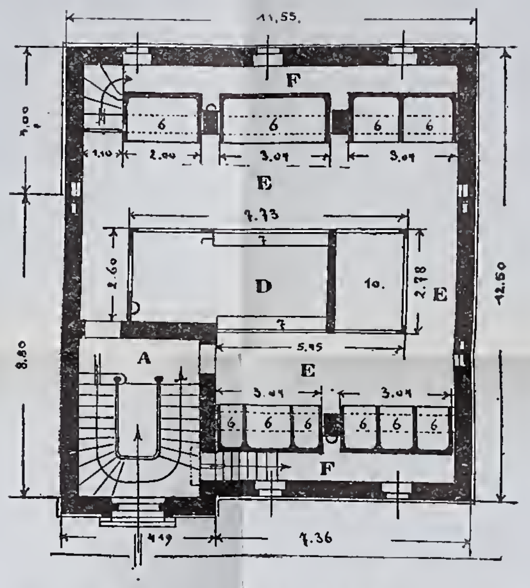


FIG. 3.—GROUND FLOOR, AT LEVEL OF EXHIBITION AQUARIA.

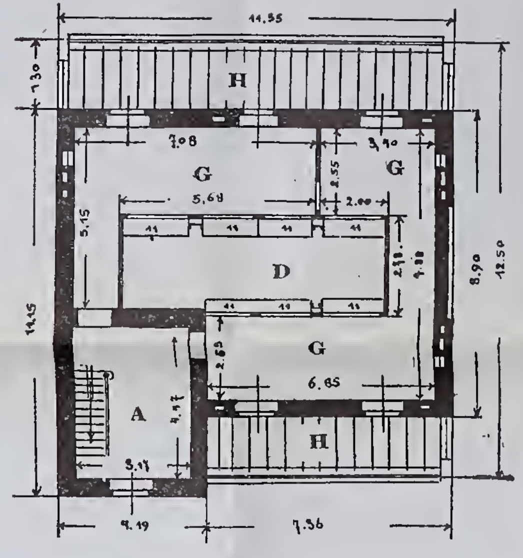


FIG. 4.—UPPER FLOOR.

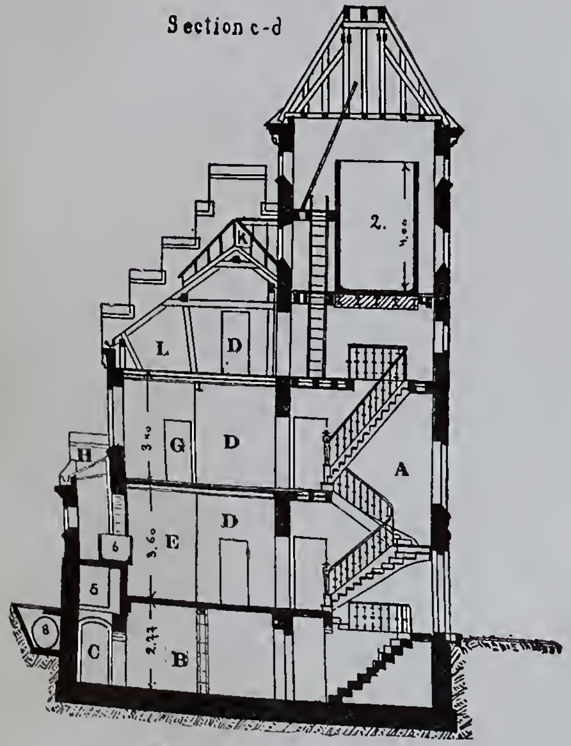


FIG. 6.—SECTION AT *c—d* (FIG. 1).

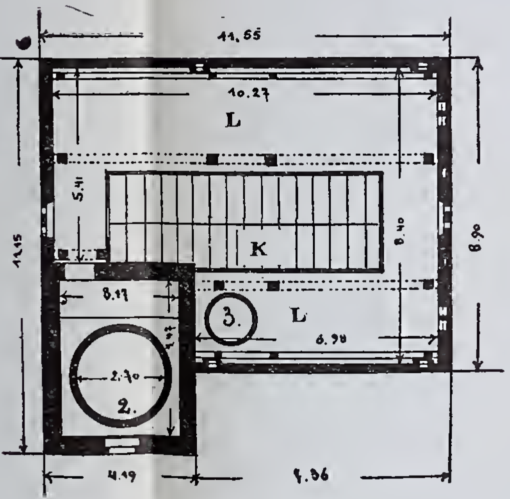


FIG. 5.—ATTIC FLOOR.

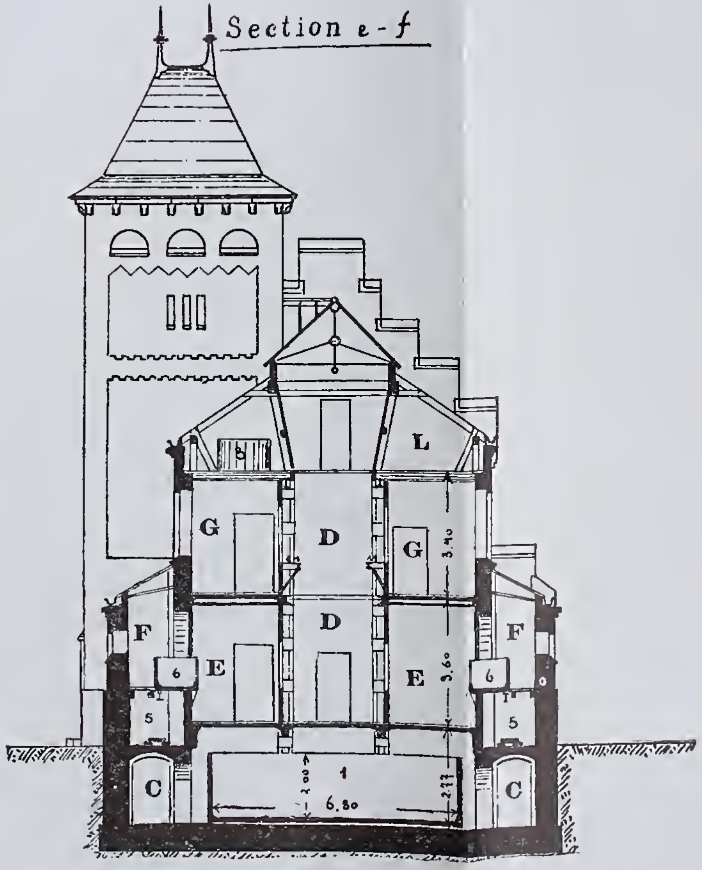


FIG. 7.—SECTION AT *e—f* (FIG. 1).

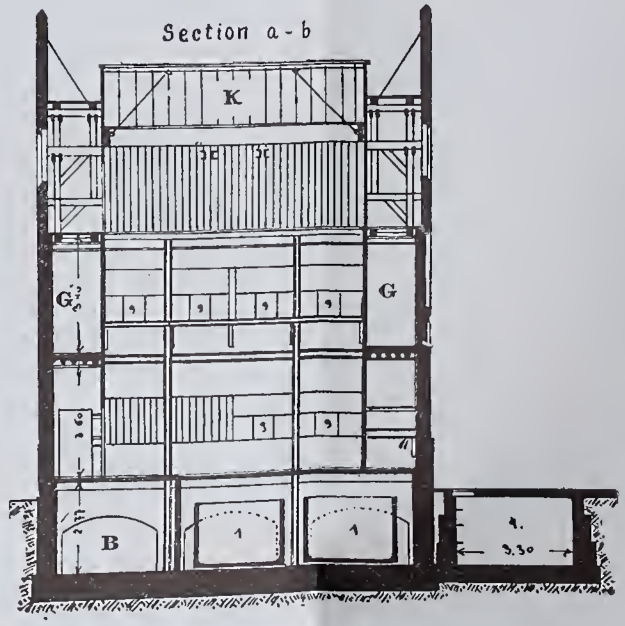


FIG. 8.—SECTION AT *a—b* (FIG. 2)

1, Low-level reservoir for sea water. 2, High-level reservoir for sea water. 3, High-level reservoir for fresh water. 4, Fresh-water cistern. 5, Filter beds. 6, Exhibition aquarium tanks. 7, Movable exhibition aquaria. 8, Benzine tank. 9, Small movable aquaria. 10, Large aquarium tank. 11, Glass troughs for small aquaria in light shaft. A, Stair well. B, Engine room. C, Corridor. D, Light well. E, Exhibition room. F, Service corridor to aquaria. G, Laboratories. H, Overhead windows on light well. L, Attic room.

PLANS OF HELGOLAND AQUARIUM. ALL MEASURES IN METERS.

By courtesy of the Director of the Helgoland Station.

birds, a phenomenon which has made Helgoland famous for the study of bird migrations. The white shores of the "Dune," a small sandy islet much resorted to for bathing, is the only remnant left of the chalk cliffs formerly connected with the island.

The unstable nature of the shores and their rugged nature, combined with the not infrequent storms which have made the North Sea deservedly infamous, affect profoundly the shore fauna and its accessibility, and add greatly to the turbidity of the water at times of rough weather. The detritus from the disintegrating island forms, however, excellent collecting grounds for a typical marine bottom fauna undisturbed by fresh and brackish waters or by the sewage and industrial wastes of a large population. The thriving lobster fishery of Helgoland is a good index of the abundance of animal life in the sea about it. Its distance (50 km.) from land gives to the plankton of the sea about it an oceanic facies and relatively small proportion of neritic additions. It is unique among stations in northern waters in this particular.

No approximate inventory has been made of the shore and bottom fauna, but a series of monographic reports on various groups is appearing in the "Wissenschaftliche Meeresuntersuchungen" under the title "Beiträge zur Meeresfauna von Helgoland" and "Beiträge zur Fauna der südöstlichen und östlichen Nordsee." In the former series papers on the fishes, mollusks, Copepoda and Cladocera, Coelenterata, pelagic Protozoa and Rotifera, rhabdocoele Turbellaria, Cumacea, Schizopoda, Cirripedia, Hydromedusae, Amphipoda, *Dinophilus*, Caprellidae, ascidians, *Phoronis*, and *Actinotrocha*, and in the latter series on the sponges, Echinodermata, Bryozoa, Copepoda, Cladocera, Hydroida, and Polychaeta have appeared. Extensive lists of the seasonal occurrence of plankton organisms in North Sea waters appear in the "Bulletin" of the International Commission for the Investigation of the Sea, and a systematic account of the various groups of plants and animals found therein is in process of publication in "Nordisches Plankton" of Brandt and Apstein. Many papers on the egg and young of fishes and the biology of the food fishes of the North Sea will be found in the "Wissenschaftliche Meeresuntersuchungen." The marine algæ of Helgoland have been dealt with as a whole and often in detail by Doctor Kuckuck in a series of papers in the same journal.

The temperatures of the sea range from winter minimum of 3.8° to summer maximum of 17°, with yearly mean of 12.4°. The specific gravity of the water ranges from 1.0224 to 1.02875, varying with the general circulation in the North Sea. Aside from the turbidity occasioned by storms, the purity of the water available at Helgoland for cultural and experimental work leaves little to be desired. The tidal amplitude at mean tide is 2.3 m., with a maximum at spring of

4.8 m. The depths available near the islands are predominantly 20 to 30 m., but reach an extreme depth of 55 m. about 15 km. to the south.

The Helgoland station offers exceptional opportunities for the study of marine plankton, of the natural history of fishes, of marine algæ, and of bird migrations. Its remarkably complete outfit of fishing appliances and the lines of investigation in progress by its staff render the station one of the foremost centers in Europe for an insight into the intensive and efficient application of modern scientific methods to the problems of sea fisheries.

Literature: Heincke (1892, 1893, 1893a, 1894, 1897), Dean (1894), Danckwardt (1905), Hartlaub (1896, 1902), Kuckuck (1893, 1897), Sand (1897), Henking (1899), and Ehrenbaum (1901).

INSTITUT FÜR MEERESKUNDE, BERLIN.

Director, Prof. Dr. Albrecht Penck, Institut für Meereskunde.

A logical and characteristic expression of the spirit of modern Germany is to be found in the Institut für Meereskunde, which was established in 1900 in connection with the Königliche Friedrich-Wilhelms Universität at Berlin. The rise of Germany as a maritime power has been illustrated by the marine expositions at Berlin in the winter of 1897–1898, and again in the summer of 1908. The first exposition led to the establishment of a permanent marine museum and the second contributed largely to its expansion. In 1898 the German naval bureau together with the Prussian Kultus Ministerium undertook the establishment of an oceanographical institute in conjunction with some Prussian university, plans for which were drawn up by Prof. E. v. Drygalski and E. v. Halle, with the later cooperation of Freiherr v. Richthofen. The enterprise had from the beginning the deep personal interest and cooperation of the German Emperor. It finally took the form of the Institut für Meereskunde.

In 1906 the Museum für Meereskunde connected with it was opened in the building of Georgenstrasse formerly occupied by the chemical laboratory of the university. The purpose of the museum has been stated by its director, Doctor Penck (1907), to be "to inspire and to diffuse far and wide in the German Nation by means of its exhibits a conception and understanding of the sea and its phenomena, the means employed in its exploration, the wealth of its life, and its economic value, as well as the social and national significance of navigation, marine commerce and sea power." "Deutschland zur See" is its motto.

This end has been sought by the almost lavish installation of exhibits which reveal everywhere the combination of technical skill and broad scientific knowledge and direction, together with a remark-

able freedom from conventional methods in design and execution of the displays.

The exhibits are found on the two lower floors of the building, and offices, library, and laboratories are on the third floors. The whole of the first floor and part of the basement is given over to most complete and elaborate display of the German naval and marine interests along historical, structural, and mechanical lines. The second floor contains the exhibition of harbor construction, light-houses, and life-saving equipment, and the scientific departments of special interest to those concerned in marine investigations. The first of these is the collection of nautical and oceanographical instruments and the oceanographical exhibit. The display of charts, compasses, sextants, chronometers, klinometers, and ship's logs is extensive and complete. In adjacent rooms 3 to 6 is to be found a most excellent and an almost historically complete collection of the instruments devised for deep-sea exploration. Sounding leads, pressure tubes, and bottom samplers from the time of the expeditions of the *Challenger* (1872–1874) and the *Gazelle* (1874–1876) down to all the varied patterns of the cable-construction companies and recent deep-sea expeditions are here displayed, together with sounding wires, cables, and weights, sounding machines of various types, Thomson, Lucas, Sigsbee, Le Blanc and others, exhibited either by photographs and diagrams or as actual instruments. There is also an exhibit of typical bottom samples as collected by the merchant marine. The study of the physical and chemical conditions in the sea is elucidated by a unique collection of instruments. Pressure and reversing thermometers of the Six, Miller-Casella, Negretti-Zambra, Knudsen, Chabaud, Richter, and other types are shown, together with instructive exhibits of the effect of pressure at great depths of the sea in crushing instruments. Scales for recording the color of the sea water and apparatus for determining its transparency are exhibited near the windows of the room. The apparatus used in determining specific gravity and salinity is also found here; self-closing water samplers of the Meyer, Sigsbee, and Pettersson-Nansen patterns for bringing up water from any desired depth without contamination from other levels, areometers, pycnometers and apparatus for chlorine (Knudsen) and gas (Fox) analysis.

In an adjacent room are meteorological instruments together with an exhibit of hydrographical instruments such as drift bottles, wave meters, tidal registers, and current meters of Aimé-Irminger, Massee, Arwidson, Nansen, Ekman, Pettersson bifilar, and other patterns for submarine exploration.

The collection of biological gear and tackle is much less complete and less advantageously displayed. There are samples of dredges, tangles, trawls, tow nets, plankton nets of Hensen, closing net of Nansen, and young-fish net of the Helgoland pattern.

The oceanological exhibit in rooms 8 and 9 is original in design and execution and contains most unique and instructive displays designed to facilitate by comparative methods the quick and easy comprehension of the fundamental facts of oceanography. Marble blocks are used to illustrate the relative volumes of the globe, the sea, the land above sea level, and in the continental blocks (above 2,300 m. below sea level). In a similar way their relative weights and those of the atmosphere and the dissolved salt in the sea are shown, as are also the quantity of salt and the proportions of the various substances dissolved in sea water. A very striking illustration of the quantity of salt in the sea is shown by comparison to scale of the thickness of the crust left on the sea bottom on evaporation of the sea with a model of the royal castle at Berlin to the same scale. The relative elevation of the continents and depths of the sea are shown by plastic reliefs. Models of a trans-Atlantic liner on columns of blue glass bring in vivid contrast the conditions as to depth in the North Sea, the Atlantic, and the greatest known oceanic depths. Movable mechanisms illustrate wave motion, while the effects of breakers on steep and flat coast lines is shown by photographs and examples of erosion.

The biological exhibits are unique in their purpose and design. There is little attempt at a systematic exhibit of marine fauna, the whole selection and grouping of the collections being subordinated entirely to securing a representation, as nearly normal as possible under the limitations of space and condition of the material, of the characteristic assemblages of marine animals and plants. Numerous tanks of considerable size contain displays of faunal types in alcohol or formalin in natural groupings and environmental effects. Dried collections and the taxidermist's art were also used in larger exhibits, as, for example, in a most excellent portrayal of a coral reef from the Red Sea. Ten small "alcoholaria" give vivid pictures with much of the original color preserved, of the minor types of faunal assemblages such as the sea urchins and sea roses (*Crambactis*) with symbiotic fish (*Amphiprion*), giant mussels (*Tridacna*), corals and parrot fish, the madropore area, the rock fauna, the regions of dying and of dead corals, and the plant life of coral reefs. In like spirit and perfection of technique are portrayed the fauna of the Antarctic icebergs, the sponge beds of the Ægean Sea, the fishing grounds off Helgoland, the pelagic world, the sandy grounds, the rock pools, oyster beds, limestone cliffs, and the fishing banks of the North Sea. The œcological interrelations of the marine fauna are suggested by exhibits of the food of well-known fish. The economic values and uses of the products of the sea are concretely illustrated in striking manner by transparencies, and by exhibits of the crude

materials and various stages in their manufacture into finished products of art or industry.

The fisheries section is rich in well-displayed exhibits of most of the devices known to man from the earliest times to the present for the winning from the sea its rich booty, examples of boats, gear and tackle, photographs, transparencies, and oil paintings of their use, models showing boats and fishing gear in action, and the homes of fisher folk.

The wonderfully rich and exceedingly varied exhibits of this museum, centered as they are around the idea of the utilization of the sea, that least known and last to be conquered part of the globe, give even to the museum-weary traveler a new and inspiring conception of the magnitude and diversity of the resources of the sea and the complexity and attractiveness of the national, commercial, industrial, and scientific problems connected therewith.

That the museum has accomplished its purpose in stimulating popular interest and enthusiasm in marine matters is attested not only by recent German political history, but also by the 100,000 persons who thronged its rooms in the first year it was opened to the public, and in the interested groups of visitors who still frequent its halls. The exhibits are free to the public, special days are reserved for classes, photographing and sketching are encouraged, and popular lectures are given on subjects allied to the purpose of the museum, for which a very extensive collection of lantern slides has been made.

A number of courses in oceanography and related subjects in the University of Berlin are given at this museum.

The publications of the museum include, in addition to the illustrated guides, a popular series, "Meereskunde, Sammlung volkstümlicher Vorträge zum Verständnis der nationalen Bedeutung von Meer und Seewesen," 12 parts yearly from 1897, and more scientific series, "Veröffentlichungen des Instituts für Meereskunde und des Geographischen Instituts an der Universität Berlin."

Bibliography: Penck (1907, 1907a).

ROYAL PRUSSIAN INSTITUTE FOR INLAND FISHERIES, FRIEDRICHSHAGEN AM MÜGGEL-SEE, NEAR BERLIN.

Director, Prof. Dr. Paul Schiemenz, Königliches Institut für Binnenfischerei, Friedrichshagen bei Berlin, Preussen. Also Kgl. Landwirthschaftliche Hochschule, Berlin, N. 4, Invalidenstr. 42.

Chemist, Doctor Kornage, Friedrichshagen.

Zoologist, Doctor Torlitz, Friedrichshagen.

Pathologist, ——— ———.

Assistant (voluntary), Doctor Korb.

In 1893 the German Fisheries Society opened on Müggel See a biological station, "Die Biologische und Fischerei-Versuchs-Station,

Müggel See," adjacent to the newly opened Berlin city water works, with Prof. Dr. J. Frenzel as director. The station was supported by the Fisheries Society, with encouragement from the government and city authorities and friends interested in the scientific investigation of the fisheries. It was in charge of a curatorium consisting of Profs. F. E. Schulze, K. Möbius, and P. W. Magnus, of the University of Berlin, and Professor Weigelt and Herr Max von dem Borne, representing the fisheries interests. After Doctor Frenzel's death, in 1897, Dr. P. S. Schiemenz, of the Naples station and later of the Hanover Fisheries Society, was called to the directorship, and the station continued without further developments until 1906, when the enterprise passed entirely into the control of the Prussian Government. Its name was changed to the Kgl. Institut für Binnenfischerei, its income enlarged, and plans made for a new building and enlarged staff. The building was completed and occupied in October, 1908, and is at present the largest and finest fresh-water station in the world. The staff includes, besides the director, a chemist, a zoologist, and a pathologist, who devote their entire time to the work of the station. The permanent employees number four—a secretary, a watchman, a laboratory helper, and a laborer.

The curatorium, consisting of professors in the university and representatives of fisheries interests, has general charge of the affairs of the station and is appointed by the Prussian minister of agriculture and education. The director is appointed by the minister of agriculture and is responsible directly to the minister. He has immediate control of the station and direction of its policy.

The budget is 22,700 marks per annum. Of this, 2,700 marks are allotted for traveling expenses, 2,640 marks for assistants' salaries, and 17,360 marks for services and upkeep.

The director holds the chair of "Fischerei und Fischzucht" in the Royal Agricultural College of Berlin and receives no salary from the station.

The institute is independent in budget and organization of all educational organizations, and as a station gives no elementary or advanced instruction. Courses in subjects related to the fisheries and the pollution of inland waters are given at the "Hochschule" in Berlin, and the practical exercises are conducted in the institute at Müggel See. The institute does not undertake to provide biological material for instruction or research.

There is room in the institute for about twenty workers. Competent investigators are admitted on application to the director. There is a small fee for admission to the privileges of the station, but workers are expected to provide their own instruments and collect their own material. The station is open throughout the year and

A. BUILDING AS SEEN FROM LAKE.

B. AQUARIUM TANKS.

INSTITUTE FOR INLAND FISHERIES AT FRIEDRICHSHAGEN.

is located in a pleasant suburb of Berlin, where living quarters are easily found.

The work of the station in the past has been of an immediately practical sort, largely concerned with an investigation of the pollution of streams by beet sugar and starch factories, and the exploration of the fisheries conditions in waters affected by commercial and industrial development. It is more concerned with the preservation and development of natural resources than with fish culture. The opening of the new laboratory makes possible an extension of the work in chemical, pathological, and biological lines.

The station issues no publications of its own. In the past the results of the investigations of its director have appeared in the "Zeitschrift für Fischerei und deren Hilfswissenschaften mit Einschluss von Fischwasser-Hygiene, Fischerei und Wasserrecht," a journal, of which Professor Schiemenz is one of the editors, issued by the "Deutsche Fischerei Verein."

The institute is located in Friedrichshagen, a suburb of Berlin, about 15 km. southeast of the city. It lies on the north shore of Greater Müggel See adjacent to the Berlin city water works, about 1 km. from the railroad station. It is easily reached by tram line No. 4, which terminates not far from the institute. The building stands in ample grounds, about 3 hectares in extent, in the margin of a forest of firs. It is about 60 m. from the water's edge and several meters above water level.

It is a handsome building (Pl. XLI, *A*) of reenforced concrete with limestone trimmings and red tile roof, built in the architectural style prevalent in the newest suburbs of the city. It faces northeast by southwest. It has three stories, cellar, and double attic, and its steep roof is crowned with a ventilating tower.

The distribution of the rooms of the two lower stories and their dimensions are shown in figures 38 and 39. The three main floors are constructed throughout on the plan of wide central corridor, lighted from the stair well, through the glazed doors of the rooms which flank its sides, and by ample windows at the end. One end of the corridor on the ground floor is utilized for an aquarium table, while the walls of that on the floor above are lined with wall cases for collections and apparatus. The arched entrance at the northern corner leads into the hall and corridor, to the right of which are the living quarters (three rooms) of the janitor, and to the left the tackle room, containing racks of wide shelves and peg racks for storage of gear and tackle, the machine shop, with forge, anvil, and tool bench. At one end of the building are laundry and toilet. Beneath the end of the building is the cellar, containing the steam heating plant and a large storeroom designed for operations, with regulated temperatures.

The other end of the ground floor contains the large aquarium room, with numerous cement floor-tanks. Because of the weight of these there is no excavation beneath this end of the building. The two projections at the end of the building contain each a small laboratory for work on the material from the aquaria.

The aquarium tanks (Pl. XLI, *B*) are of concrete, Monier system, and have walls about 6 cm. in thickness rising about 105 cm. from the floor. Their form, distribution, and dimensions are shown in the plan (fig. 38). They are supplied with overhead brass cocks and are drained through bottom outlets in which are placed vertical copper plugs of the desired height, having perforated knob-like tops.

The second story (fig. 39) contains the main laboratories of the institute arranged along the sides of the corridor, at one end of which is the conveniently located balance room, accessible alike from the two main laboratories and the corridor, and at the other end the work-room of the laboratory helper. Adjacent to this room are two retired research laboratories. Upon the northwest side of the corridor are the biological and fisheries laboratories, abundantly lighted by windows filling the entire façade with lower sashes without obstructing bars. The desks for microscopical work, with seats for ten workers, are ranged in front of these windows. Large work tables are placed in the center of the room, and hoods at the end provide for the paraffin ovens, and other apparatus requiring ventilation or protection. On the southeast side of the corridor are the well-lighted aquarium and collection room, containing tables, with overhead water supply for glass-box aquaria and others with metal frames of the conventional type. The wall cases provide for a considerable collection of fresh-water invertebrates and fishes and of plankton from Prussian waters. The walls of the adjacent corridor and stairway are also utilized for the display of biological exhibits and charts illustrating the biology of fresh waters and their fisheries and the work of the station upon polluted streams. The adjacent room is to be equipped as the laboratory for pathological and bacteriological investigations.

The chemical laboratory has two double centrally located chemical desks, ventilated hoods at the end of the room, and long work tables in front of the windows. The laboratory is equipped for water and gas analysis and for investigation of stream pollution by chemical, industrial, and municipal wastes. Adjoining the chemical and also the biological laboratory are small ventilated stench rooms for storage and examination of the foul-smelling fish, wastes, or polluted waters often investigated by the station.

The third story contains a large library and reading room with vaulted roof, the director's office, laboratory, and conference room and the living quarters of the assistants in the station. The high attic is divided into two floors, the lower containing several gable

rooms for the entertainment of workers or visiting naturalists, and the upper one being a ventilating chamber receiving the flues from

Fig. 38.—Plan of first or ground floor of Friedrichshagen Institute.

the various rooms below and discharging through the ventilating cupola which crowns the building. The building is heated by steam,

and the rooms are supplied throughout with gas and filtered water from the city mains. It is a fine example of the modern builder's art

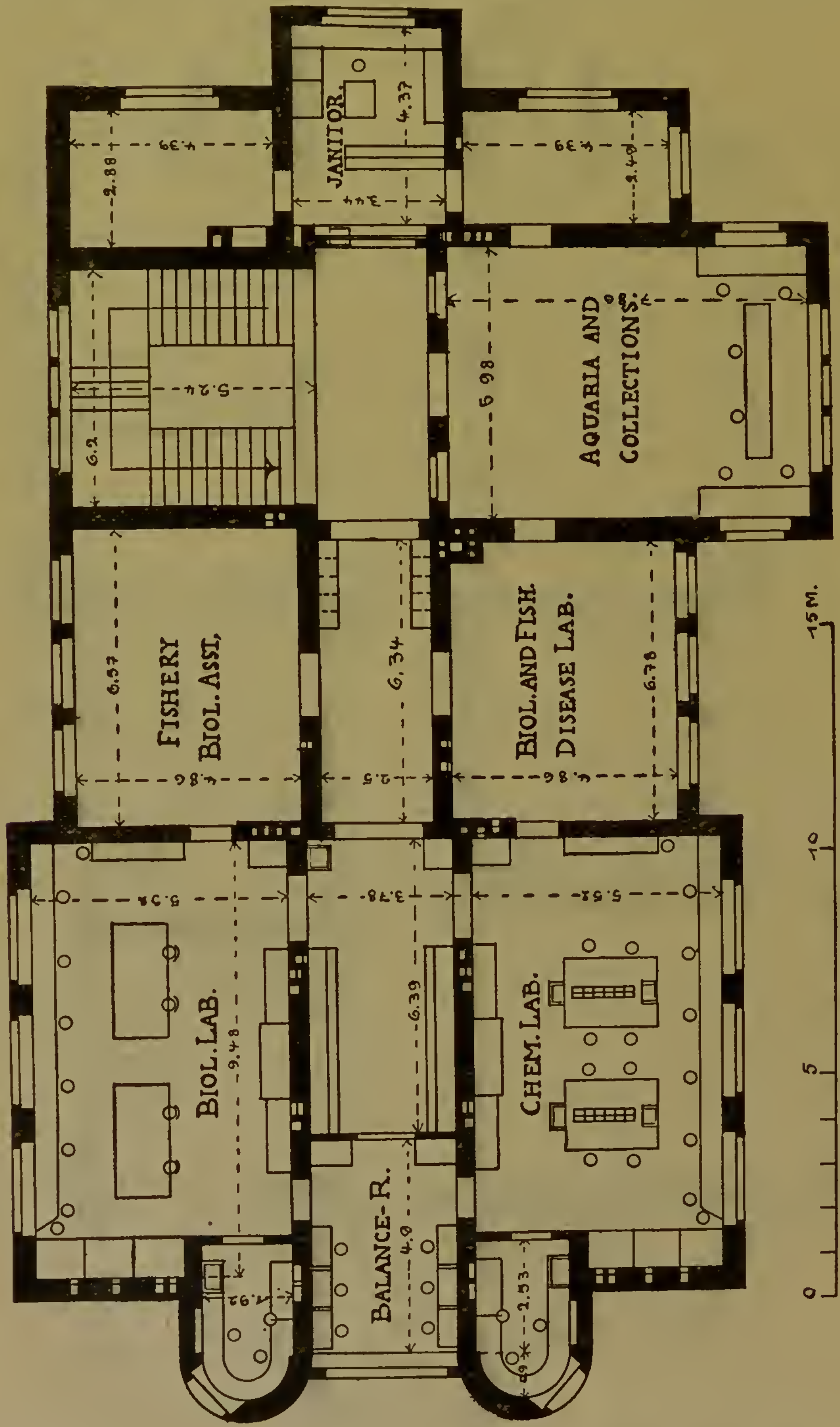


FIG. 39.—Plan of second floor of Friedrichshagen Institute.

and is admirably adapted to its purposes and is completely fitted and adequately equipped. The cost of the building, with 440.9

sq. m. of floor space and 5,528 cu. m. contents, was 135,000 marks, or 24.5 marks per cubic meter. The fittings and equipment cost an additional 80,000 marks.

The grounds of the station contain also the small building (7.5 by 11.5 m.) formerly occupied as station, the boathouse, and a series of seventeen natural or artificial fish ponds and culture basins for purpose of experiment and observation. It possesses several row boats and small power launch (1.5 by 11.5 m.) with a 4-horsepower motor, and is equipped with an ample outfit of the usual collecting apparatus. It has a small library of works pertaining to fresh-water fisheries.

Müggel-See is a widened portion of one of the divided channels of the river Spree, and is therefore a small lake traversed by a considerable current. It lies in a territory rich in similar expansions of the Spree and in small lakes and streams where fresh-water fisheries flourish. It is a body of water 4,500 m. long and 3,000 m. in width, an area of about 700 hectares, and a maximum depth of 8 m. It possesses a rich plankton, some marginal vegetation and an abundant fish fauna. A full account of the physical conditions and notes on the fauna and flora will be found in the papers of Frenzel (1895) and others in the Zeitschrift f. Fischerei.

Literature: Anon. (1908), Frenzel (1895), Ward (1900).

ROYAL BAVARIAN BIOLOGICAL EXPERIMENT STATION, MUNICH, GERMANY.

(Kg. Bayerische Biologische Versuchstation.)

Located at the Kgl. Tierärtzlichen Hochschule, Veterinärstrasse 8, near the English Garden.

Director, Prof. Dr. Bruno Hofer, professor of zoology in the Kgl. Tierärtzliche Hochschule at Munich.

Assistant for fish diseases, Dr. Marianne Plehn.

Assistant in biology, Dr. E. Neresheimer. (See Fisheries Station, Vienna, p. 272.)

Chemist, Dr. Fr. Graf.

Assistant chemist, Dr. A. Strell.

Scientific associate in fish culture, Dr. Wather Hein.

Scientific associate in physiology, Dr. Hans Reuss.

The commercial development of modern Germany has brought into existence not only great industrial centers like Berlin, but also a host of smaller factory towns and isolated plants scattered throughout the land, and often located upon or near streams. The prominence which the chemical industries have attained is only paralleled by their wide distribution, all too often along the rivers or within reach of running water. Germany has thus been brought face to face with the vital question of the protection of public and private interests in her water courses, the preservation of her fresh-water fisheries, and the prevention of the pollution of lakes and rivers by the sewage of cities and the

wastes of factories and industrial plants. The problem has been approached from the engineering and sanitary standpoints in relation to questions of water supply and sewage disposal, often to the neglect in Germany, as elsewhere, of the biological problems involved, the analysis of which is contributory in no small way to the solution of the difficulties.

The Bavarian biological station prior to the recently developed Prussian "Institut für Binnenfischerei" was unique among the scientific agencies engaged in the attack upon the intricate problems of stream pollution resulting from our complex modern industrialism in that its point of view is biological. It seeks to devise ways and means by the technical application of science to preserve and develop the fresh-water fisheries, to prevent the pollution of waters and the destruction of fish by industrial wastes by rendering these harmless through mechanical or chemical treatment, or by forbidding their admission where correction is impossible. To this end it has become a state bureau, with advisory relations in all matters of legislation and police control, and is clothed with powers of supervision over all waste waters from municipal, industrial, and private sources entering the streams of Bavaria. It is active not only in the detection of sources of contamination, but also in experimentation to discover means of relief without loss to either fisheries or factory. Two of the important lines of investigation in progress are the rendering innocuous the wastes of cellulose factories and the investigation of sewage from country places, and even from Munich itself, in carp culture.

Another line of investigation followed with preeminent success has been the study of the diseases of fish and invertebrates of economic importance. It is to this laboratory that we owe the discovery of cancer in fishes. Its researches in this line are affiliated with those of the Bavarian committee for the investigation of human cancer. The director of the station, Doctor Hofer, is himself the author of the only scientific treatise on the diseases of fishes. Its service in this field is not limited to Bavaria or Germany, but is in fact international.

It also deals with the practical question of fish hatching and fish culture—the introduction and acclimatization of food fishes. To this end a biological laboratory which deals largely with the biology of fishes is maintained and forms a bureau for consultation in all matters pertaining to the fisheries. The physiological problems relating to the action of the chemicals of industrial wastes upon fish and other organisms of fresh water, and questions of nutrition and growth under cultural conditions, afford fruitful field in which active investigation is carried on.

The Bavarian biological station is largely the outgrowth of the scientific activity of the present director, Dr. Bruno Hofer, and is at

present an institution for scientific research of high order on broad foundations and intimately correlated with the solution of practical problems. It originated in 1897, when the German Fishery Society established a biological station for the investigation of fish diseases, to which Professor Hofer was called as director and Dr. Fr. Doflein as assistant. It was located in the zoological institute of the University of Munich, and was under the charge of a curatorium or scientific board of control, consisting of Professor Buchner, of the hygienic institute; Prof. R. Hertwig, director of the zoological institute of the university; Professor Voit, director of the physiological institute of the veterinary school; Doctor Hofer and representatives of the Bavarian Ministerium; the Bavarian Fisheries Society; and the secretary of the German Fisheries Society. This curatorium, with some increase in the Bavarian representation, has been continued. It has advisory control of the general plan of work of the station and supervision of the annual budget and expenditure. The director makes an annual report to the curatorium.

Its work has gradually enlarged, and its staff has been increased accordingly. In 1900 its present name was assumed, and with the establishment of a zoological institute at the Royal Bavarian Veterinary Hochschule, to which Doctor Hofer was called, the fisheries station was moved to that institution, and now occupies five rooms adjacent to those of the zoological laboratories. Its physiological investigations are, however, carried on in the physiological laboratory of the Hochschule. while its field experiments in fish culture of the Salmonidæ are conducted in a hatchery and breeding ponds of ample extent at Mühlthal, near Munich.

The Bavarian biological station, as such, has no concern with instruction, this being given under the auspices of the veterinary Hochschule. It is purely a research institution, and its relations to the fisheries and to the Hochschule are similar in many respects to those of our own agricultural experiment stations to agriculture and to our agricultural colleges. This type of organization has resulted in the case of the Bavarian station in progress of high order, in the application of scientific methods to the solution of the practical problems of the fisheries.

The equipment of the Bavarian biological station does not differ in essential particulars from that of a modern biological laboratory. It is amply supplied with aquaria in which the various fish and invertebrates under investigation are kept with good success. This is especially valuable in connection with the study of fish diseases. One of the conditions of success has been the rather feeble illumination in which the aquaria are kept. The aquaria are shown in figure 40.

The aquaria are aerated by a Kindel and Stoessel's Durchluftings-apparat operated by the water pressure in the city mains, or by air introduced with the inflowing water by Körtings Luftbrause, a form of Sprengel pump adapted to the purposes of aeration. The method of distributing the discharge in the aquarium is shown in fig. 40.

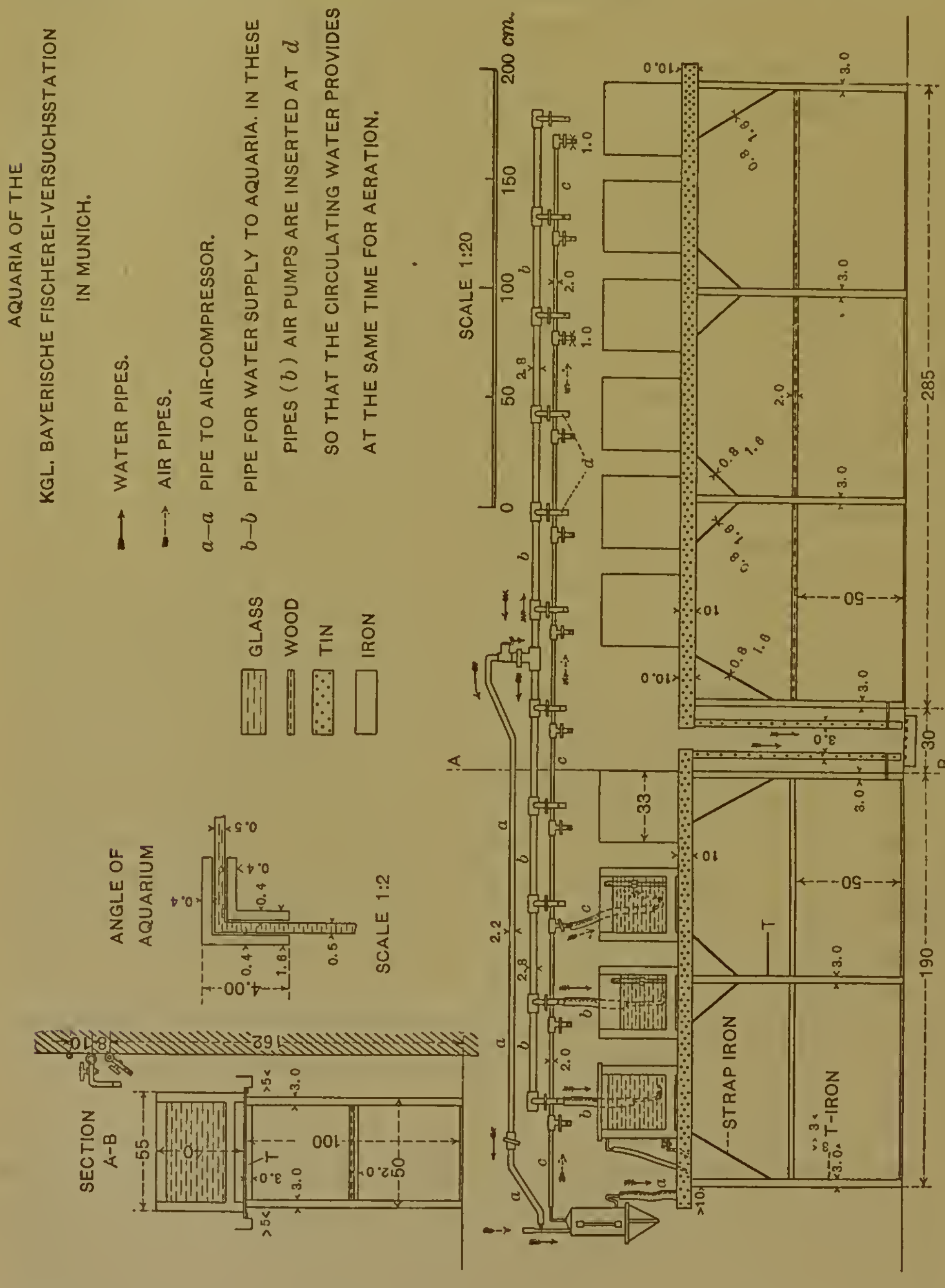


FIG. 40.—Plan of aquarium in Biological Experiment Station at Munich.

For the purpose of shipping living fish, especially diseased specimens, to the laboratory for examination, shipping tanks of the form usually employed for the transport of living fish to market are used with the addition of an apparatus for supplying oxygen continuously, known as Kaltonegger's Hydrobionapparat.

The station has an annual budget of 27,000 marks, 5,000 of which is a private grant for the support of the Multhal experimental plant, and of the remainder 5,000 comes from imperial funds and 17,000 from those of the Bavarian State.

The station has but limited quarters, only five tables or places being available. These are open without charge to fully competent investigators wishing to work along the lines with which the station is occupied. Applications should be made to the director as far in advance as possible.

The results of its investigations are published in the "Berichte d. kgl. Bayerischen Biologischen Versuchstation" (1908) and in preliminary accounts and in annual résumés in the Allgemeine Fischerei Zeitung.

Literature: Hofer (1897, 1898, 1901, 1902, 1903, 1904, 1906).

BIOLOGICAL STATION AT PLÖN, EAST HOLSTEIN, GERMANY.

Director, Prof. Dr. Otto Zacharias, Plön.

This pioneer fresh-water station was founded in 1890 by its present director, Professor Zacharias. The village of Plön gave the site and erected the building. Gifts from private individuals, fishery organizations, and learned societies to the amount of 11,000 marks provided for the equipment, and the Prussian ministry of education granted an annual stipend of 5,000 marks.

The station has no official relations with universities or fishery boards, but is rather of the nature of a private laboratory with state support. Beginning in 1909, vacation courses of three weeks' duration each are offered by the director during the summer months in hydrobiology and planktology, designed especially for teachers in the middle and higher schools. A course for beginners is offered in July and an advanced course in August. The fee for each course continuing three weeks is 50 marks. Students provide their own equipment of instruments and glassware, but material and reagents are furnished for ordinary use.

The courses offered include a comprehensive survey of the biology of fresh waters, the conditions of life in the different types of environment, the adaptations which organisms exhibit to these external conditions, methods of collection, preparation and study, and the systematic examination of typical assemblages of aquatic plants and animals.

The investigations of the station are carried on by the director and occasional visiting scientists. Places for six investigators are found in the station. A fee of 10 marks per week is charged for the use of an investigator's table, including the usual preservatives and reagents. The station does not furnish microscopes or equipment. The laboratory is open from 9 to 12 and 2 to 5 on week days, and the best

months for work are July–September. Applications for admission should be sent in advance to the director. The station has been utilized in the past by many investigators from many lands.

The systematic and comprehensive investigation of the life of fresh waters received substantial and lasting stimulus from this station, the first to enter the field in an organized and permanent manner. Its work has been of a biological character, centering about the study of the life of fresh water in its relations to environment. Especial attention has been paid here to the study of the plankton. The results of these studies have been published in the "Forschungsberichte" of the Plön station (1893–1903, Bd. 1–12), and since 1906 in the quarterly periodical known as the "Archiv für Hydrobiologie und Planktonkunde" (1906–1909, Bd. 1–5).

The building of the Plön station is located on the north shore of the Greater Lake of Plön, a few minutes walk from the railroad station. It is a plain villa of brick, of three stories near the water's edge. Upon the ground floor are found the laboratory, a well-lighted room with places for six workers, and the library. Numerous aquaria supplied with running water are found in the basement, where is also located the pump room with petrol motor. The upper stories are used as the residence of the director. A wooden building near the station with places for 30 students is utilized as a laboratory for the vacation courses.

The station is provided with the necessary chemicals and glassware and the special apparatus needed for usual forms of biological research in fresh waters, with a microphotographic equipment, plankton nets of the Apstein and other patterns and with various forms of special apparatus devised for the biological investigation of the open water, shores, and bottom of the lake. There are also row boats, a sail boat, and motor boat for excursions to collecting grounds.

The Plön station has an exceptionally well chosen situation in the lake district of Holstein, within a short distance of over twenty lakes of various sizes, numerous marshes, and fish ponds. The lake upon which it is situated has an area of 30 square kilometers, and a maximum depth of 60 meters. A full account of its fauna and flora will be found in the earlier volumes of the Forschungsberichte.

Literature: Sand (1897), Ward (1900), Zacharias (1888, 1889, 1891, 1892, 1903, 1905a).

POND-CULTURE STATION IN TRACHENBERG.

Director, Prof. Dr. C. Hoffbauer, Teichwirtschafliche Versuchsstation der Landwirthschaftskammer für die Provinz Schlesien, Trachenberg, Schlesien, Deutschland.

This station was founded in 1895 by the "Schlesischen Fischereiverein" and in 1905 its support and direction were assumed by

the agricultural bureau of the province. Its function is two-fold—first, as an experiment station for the investigation of the problems of pond culture, especially those pertaining to the growth and feeding, natural and artificial, of the carp and other pond fishes, the relation of pond fertilization to plankton production, studies of the relative values of different races of carp under culture and determination of ages and rates of growth by a study of the scales of fishes. It is to Doctor Hoffbauer that the discovery of this method of determining the age of fishes is due.

The station is located about 4 km. from the city of Trachenberg. Its plant consists of 16 culture ponds, varying in size from 400 to 4,900 sq. m. A transportable field laboratory and aquarium house is used in the field studies. In the city of Trachenberg the station has an office and laboratory where the collections are kept and an adjacent lecture hall where the courses in pond culture are given annually, generally in May or June. This instruction, the second function of the station covers the subjects of fresh-water food fishes, their culture, the life in streams and ponds and its relation to fishes, plankton studies, fish feeding, and pond fertilization, construction of fish ponds, and enemies and diseases of fishes, with demonstrations and excursions to the station and neighboring culture ponds.

Literature: Hoffbauer (1899, 1903, 1906).

HANNOVERIAN POND CULTURE STATION NEAR WAHRENHOLZ, HANNOVER.

Director, E. Giesecke, Landwirtschaftskammer für die Provinz Hannover, 11 Leopoldstrasse, Hannover, Deutschland.

The agricultural bureau of Hannover has recently purchased on the Lüneburg Moors, 5½ km. west of Wahrenholz, a tract of 400 acres, in which it has opened an extensive series of concrete and open culture ponds, the largest experimental plant of the sort in Europe. This station lies in the midst of a barren tract of land in which there has been in the last ten years a remarkable development of the pond culture of carp, German and Crucian, tench, brook and rainbow trout, and the saibling, over 3,300 ponds being now under culture. A biological station with scientific staff is projected in connection with the enterprise.

Literature: Dorse (1907).

INVESTIGATION OF THE LOWER ELBE.

Director, Prof. Dr. K. Kraepelin, Naturhistorisches Museum, Hamburg, Deutschland.

Assistant, Dr. Richard Volk.

Since 1899 the city of Hamburg has maintained, in connection with its natural history museum, a department devoted to the scientific

investigation of the extensive system of waterways, natural and artificial, connected with the lower course of the Elbe. The problems here investigated are those arising in connection with the disposal of sewage in this ramifying system of streams, lakes, and canals, in its bearing upon questions of sanitation and fisheries, the effect of the movement of large vessels in narrow channels upon the fisheries, and the biological problems of the effect of great quantities of sewage discharged at the mouth of a large river upon the life of the stream, both in the territory involved and in the upper reaches of the river, and the interrelations of the marine, brackish, and fresh-water faunas and floras in a tide-swept estuary. The methods and apparatus employed are those of a biological station.

Doctor Volk has perfected an efficient set of apparatus for the quantitative investigation of the plankton and a microscope for the statistical examination of plankton collections. (See Volk, 1901, 1906.)

A method of determination of the smaller organisms which escape through the finest silk net has been perfected by Doctor Volk, using sedimentation, filtration, and decantation, as well as the centrifuge in their collection and condensation.

The laboratory of the Elbe investigation in the natural history museum contains the apparatus perfected by Doctor Volk, extensive collections of the fresh and brackish water plankton of the Elbe, and a superb collection of microphotographs of the plankton.

Literature: Volk (1901, 1903, 1906, 1908).

CHAPTER VI.

AUSTRIA-HUNGARY.

The development of biological stations in Austria-Hungary has been largely influenced by certain more or less combined factors of economic interests, field study and exploration, the collection of biological supplies, and the promotion of independent centers of research. The initial movement in the establishment of the marine stations at Trieste (1875) and Fiume (1905) arose from a need of educational institutions for outposts at the seashore for the supply of biological material for laboratories of instruction and research and for vacation investigations of members of their teaching forces and seaside courses for students.

The Rovigno (1870 at Trieste, 1892 at Rovigno) station had its origin as a collecting center for the supply of biological material to the Berlin and other aquaria, and subsequently added to this the facilities for research.

The conception of the biological station as primarily an independent and self-sufficient center of research is fully exemplified in the fresh-water station at Lunz (1905) and the biological experiment station at Vienna (1903), as well as in the hydrographic-biological programme of the Adria Verein carried out at the Trieste station.

The fresh-water stations at Pocernitz (1892) and Hirschberg (1906) are outposts of university laboratories engaged in exploration, while that at Frauenberg (1906) and the fisheries laboratory at Vienna (1909) are the only stations in which the economic factor has had the controlling interest.

BIOLOGICAL EXPERIMENT STATION IN VIENNA.

Vivarium, Haupt-Allee, K. K. Prater, Wien, II; Biologische Versuchsanstalt.

Directors: Dr. Hans Przibram, zoological division; Dr. Wilhelm Figdor, botanical division; Herr Leopold v. Portheim, botanical division; Dr. Wolfgang Pauli, physical-chemical division.

Assistants in zoology, Dr. Paul Kammerer, Dr. Franz Megušar.

Assistant in fresh-water investigations, Dr. Josef Brunnthaler (in connection with the Ackerbauministerium).

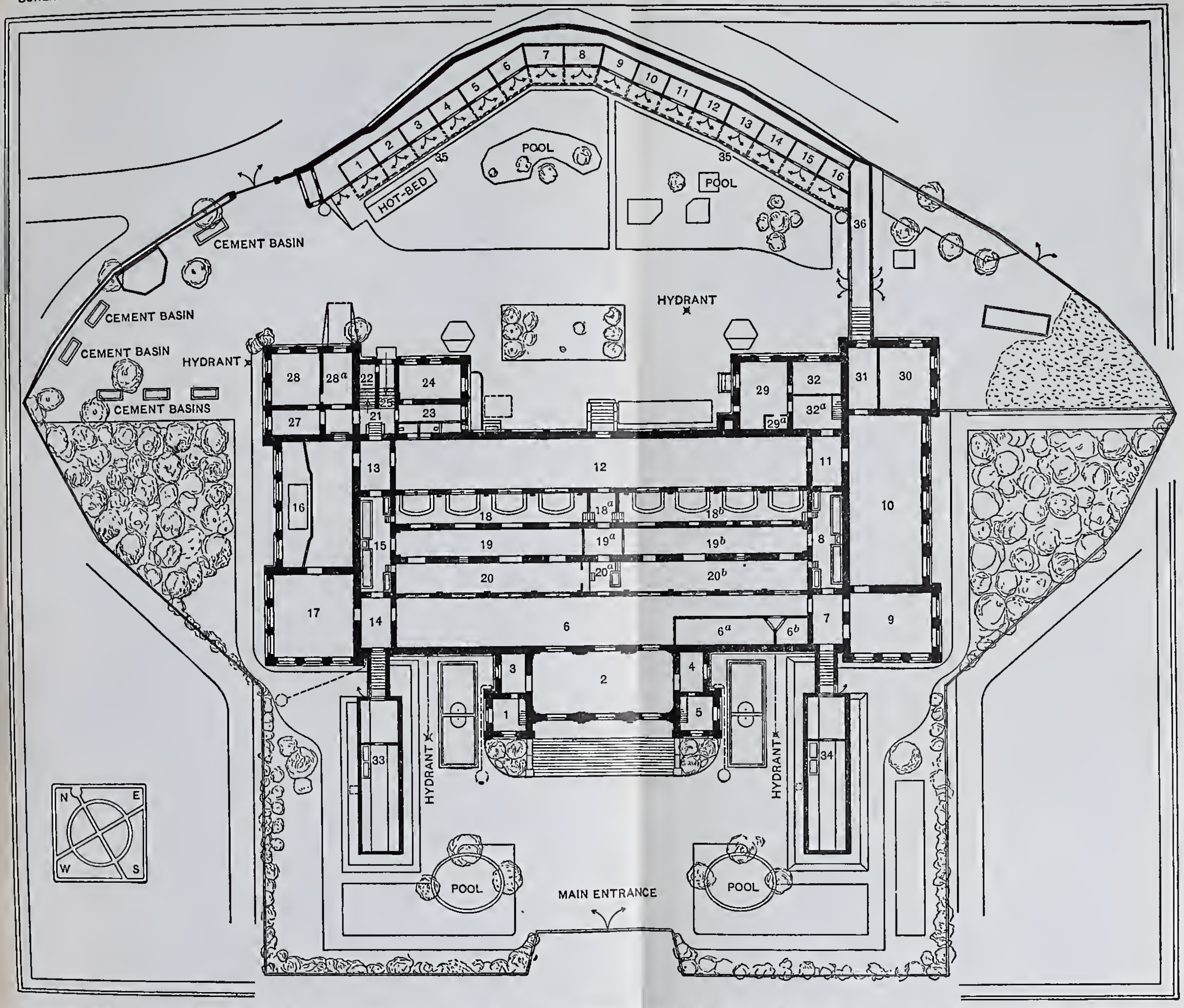
The station was opened June 1, 1903, on the banks of the Danube in the great city park known as the "Prater," in the grounds occupied by the "Vivarium" of the exposition of 1873. The grounds

were leased from the Crown by Doctors Przibram and Figdor and Herr v. Portheim, and the buildings and grounds remodeled and equipped for the purposes and uses of the experiment station with private funds. The institution is private, under the control of the directors above named, and is supported by private funds. It is, however, the recipient of public funds from the Kultus Ministerium, supporting six tables for investigation—two in zoology, two in botany—under the control of a curatorium consisting of Professors Grobben, Hatschek, Wettstein, and Wiesner, of the University of Vienna, one in the physical-chemical section controlled by the medical faculty, and one in fresh-water investigations supported by the ministry of agriculture. The grant per annum for a table is 1,000 kronen. In addition a grant of 2,000 kronen is made for the purchase of living material supplied to educational institutions.

The institution has at its disposal thirty-five tables for investigation, principally in biological lines. Its facilities are utilized annually by over fifty persons. The institution is open throughout the year, and places are free, without fees, to students working under the charge of the directors. Independent investigators pay a fee of 1,000 kronen per year. Competent investigators are admitted to the privileges of the laboratory on application to the directors.

The experiment station is exclusively a research institution without organic connection with other educational institutions, although its directors are members of the faculty of the University of Vienna. It provides no instruction and has no economic interests to serve beyond administering a grant for the investigation of fresh waters conducted by one of its assistants. It is thus untrammeled by hampering obligations and is free to direct its energies to the solution of biological problems in whatever way and with whatever material is most promising, free from the interruptions incidental to educational work and without regard to immediate economic ends. The experimental method, which has arisen to such prominence and promise in the last score of years in the field of biology, has for its field the determination of the causes which underlie the origin, continuance, and degeneration of organic forms. It includes within its scope experimental morphology, developmental mechanics, the border sciences of biochemistry and biophysics, and the more strictly biological field of genetics with its problems of variation, heredity, and natural and artificial selection. It is into this fertile and promising field of investigation that the Vienna experiment station enters with an excellent equipment, a broad conception of the problems to be attacked, and a location in one of the world's greatest centers of scientific activity.

The station publishes no journal of its own but the results of investigations carried on in its biological laboratories appear in the "Archiv f. Entwicklungsmechanik" under the caption of "Arbeiten der



1, 3, 4, 5, Offices of botanical division. 2, Hall. 6, Terrarium—dark passage. 6a, Constant illumination room. 6b, Biological dark room. 7, Passage. 8, Preparation room. 9, Laboratory for medium temperatures. 10, Main laboratory. 11, Passage. 12, Aquarium grotto. 13, 14, Passages. 15, Preparation room. 16, Hot room with abundant light. 17, Warm laboratory. 18, 18a, Large salt and fresh water aquaria. 19, Warm room with overhead light. 19a, Preparation room. 19b, Cold room with overhead light. 20, Warm terrarium. 20a, Passage and stairs to cisterns. 20b, Cold terrarium. 21, 22, Passage and stairs. 23, 24, Keeper's quarters. 25, Entrance to offices. 26, Reception room. 27, Zoological assistant. 28, 28a, Offices of zoological division. 29, 29a, Laboratory for physical chemistry. 30, Office of physical-chemical division. 31, Corridor. 32, 32a, Balance and chemical apparatus rooms. 33, Warm greenhouse. 34, Cold greenhouse. 35, Animal houses (1 to 16). 36, Winter corridor. Out-of-door cages, terraria, etc., scattered in the rear.

PLAN OF THE VIVARIUM OF THE BIOLOGICAL EXPERIMENT STATION AT VIENNA.

zoologischen Abteilung der Biologischen Versuchsanstalt in Wien" and are also issued as a reprint series.

The building occupied by the station stands in grounds containing about 10,000 sq. m. and is surrounded by a garden in which are found the animal houses, the out-of-door cement basins, terraria of various sorts, and the greenhouses for high and low temperatures. The building itself, originally constructed as an aquarium and menagerie for exhibition purposes, is admirably adapted for the purposes of the station. It is a substantial structure (30 by 64 m.) of stone, mainly of one story.

A full description of the equipment of the establishment (Pl. XLIII) will be found in Przibram's paper (1903, 1908–9), including an account of the fresh and salt water containers and circulating system, the aerating plant, the terrarium, animal houses, greenhouses, and the special apparatus for controlling environmental factors of heat, light (including color), moisture, density, and gravity. A full account is also given of the animals and plants kept under culture, and directions for the feeding and care are quite freely described by Professor Przibram (1908–9). A few of the most important matters are the following: The fresh and salt water tanks are of cement (3 m. long, 1.7 m. wide, and 1 m. high), with circulating system (for salt water) of lead lined with tin, and all cocks are hard rubber fastened to the lead pipe by means of rubber tubing well washed out and tied on with catgut. Sea water, after use, is passed downward and then upward through sand filters upon entering the storage cistern. Small aquaria for isolation cultures are made of earthen ware and are 50 cm. long, 30 cm. wide, and 30 cm. high. These are supplemented by glass basins of various sizes. The aerating plant contains a 2-horsepower electric motor running an air compressor (Hilpert) forcing air into steel tanks under 5 atmospheres' pressure. Reducing valves discharge this at 1.1 to 1.2 atmospheres into a distributing system of iron pipes with taps at intervals for removal of water which accumulates in the pipes. The cocks are of brass and the terminals of rubber and glass tubing with plugs of charcoal, pumice, bamboo, or of rubber pipette bulbs pierced with needle holes. All iron parts throughout the aquarium equipment are coated with aluminium-copal varnish to eliminate as far as possible the deleterious effects of iron rust upon animals, especially crustaceans. The only iron used in the salt-water plant is in the pump, and this is asphalted as far as possible.

The station has built up an excellent museum illustrative of the modern work in experimental morphology and developmental mechanics. Owing to the wealth of library resources in Vienna it is providing only a working library of journals and reprints (about 1,000 volumes) pertaining to its immediate field of research.

The animals kept in culture at the station include rats, mice, dormice, and other small rodents; kangaroos, hares, turtles, lizards, snakes, frogs, toads, salamanders of various kinds, axolotl, fresh-water fish, native and tropical, meal worm, flesh and fruit flies, praying mantis, and a considerable variety of smaller fresh-water and marine invertebrates.

Literature: Przibram (1903, 1903a, 1908–9).

ROYAL ZOOLOGICAL STATION IN TRIESTE.

(K. K. Zoologische Station in Trieste.)

Passeggio San Andrea 2, Trieste, Austria.

Director, Prof. Dr. Carl I. Cori, (Deutsche Universität, Prag). House address, via Giustinelli 1, Trieste.

Assistant in zoology, Dr. Gustav Stiasny.

Assistant in zoology, Dr. H. Mikoletzky.

Assistant in botany, Dr. Josef Schiller.

Telegraph address, Aquarium, Trieste.

The foundation of the Trieste station was due to the efforts of Prof. Franz Eilhard Schulze, now of the University of Berlin, but in earlier years connected with the University of Gratz. In 1875 the station was opened in a villa, once belonging to the royal Spanish family, located upon the seashore in the suburbs of the city. From 1875 until 1898 Dr. E. Graeffe was in local charge as resident inspector of the station, and from his pen came many publications dealing with the fauna of the Adriatic. At first the station was under the joint directorate of Professors Schulze and Claus, the latter of Vienna. Later Professor Claus became sole director and continued in this relation till 1896, when upon his retirement a curatorium was established in charge of the affairs of the station.

The present board of control consists of Professors Exner, Grobben, Hatschek, Toldt, and Steindachner of Vienna, Cori and Vejdovsky of Prague, v. Graff of Gratz, and Wierzejski of Cracow. . Prof. C. I. Cori was appointed in 1898 as director in residence to succeed Professor Claus. With the new arrangement the station took on a new lease of life. A government grant of 26,000 kronen was applied to the improvement and enlargement of the buildings. An aquarium was established in the basement, physiological and chemical laboratories were opened, and the personnel enlarged to include four scientific assistants. The curatorium holds an annual session and reports directly to the minister of education, the station holding the same relation to this ministry as a university. The director reports to the curatorium and has the entire administration of the station in his hands.

The staff of the station consists of the director and three assistants and the personnel of a keeper in charge of the aquaria and the bio-

A. COLD TERRARIUM ROOM.

B. MAIN LABORATORY WITH SHELF TABLE AND AQUARIUM RACKS.

BIOLOGICAL EXPERIMENT STATION, VIENNA.

logical supply department, a machinist and engineer, and three collectors.

The receipts of the station in 1909 were 25,100 kronen, derived directly from the State and allotted as follows:

Expenditures of Trieste biological station, 1909.

	Kronen.
Salaries and wages	9,400
Upkeep	7,500
Student's stipends	1,600
Repairs	3,000
Library	2,000
Traveling expenses	1,600
Total	25,100

The director's salary is paid by the German University in Prague. No income is derived from the aquarium or from the sale of material.

Independent of the station in organization, administration, and budget is the "Society for the Promotion of the Scientific Investigation of the Adriatic." Its work is carried on at the station, whose director, Professor Cori, was a prime mover in the organization of the society. The purpose of this organization is the exploration of the Adriatic and, to this end, it has raised the funds for the construction and equipment of an exploring ship, *The Adria*, and for the expenses of the exploring expeditions, whose aim is a hydrographic and biological survey of the gulf of Trieste and adjacent waters of the Adriatic.

In the earlier years of its existence the Trieste station was inadequately supported and was concerned chiefly with supplying biological material to Austrian universities and with the instruction of university students. Its increased facilities have enlarged greatly the opportunities it offers for research.

There are twenty-four work places in all in the station, and competent investigators and students are admitted to the privileges of the station without fees or charges except for unusually large quantities of expensive chemicals, reagents, or materials. A circular of information is issued giving the details of the equipment of investigators' tables and the regulations of the station regarding the collection of material, services of the personnel, use of the library, and furnishing of laboratory supplies. Investigators and students furnish their own microscopes and instruments. Used laboratory glassware is furnished at cost. The station is thus free to all who are competent to use its resources. The station is open throughout the entire year from 7 or 8 a. m. to 7 p. m. Applications should be made in advance to the director. During the past ten years from 33 to 92 persons have availed themselves yearly of its facilities.

The Trieste station has an exceptionally important function in furnishing to Austrian high schools and universities living and

preserved marine material for biological instruction and research. By courtesy available material for research is furnished at cost to universities and investigators of all nationalities and sea water and living animals are sent at fixed nominal prices to private parties for aquaria for the purpose of extending public interest in natural history. In 1908 nearly 300 shipments of biological material were made, mainly to educational institutions.

The exceptionally fine opportunities at Trieste for the use of living material in instruction are utilized in vacation courses of five weeks' duration offered to university students twice yearly, in March–April and September–October. The courses are given by the staff of the station and are of a general character, covering the anatomy, development, and biology of marine animals and plants. The botanical courses are attended by about 10 and the zoological by about 20 students each session. The courses are free and a stipend of 1,600 crowns is available for students (90 to 180 kronen each) in attendance.

The investigations carried on at the station have been varied in character and lie in all fields of marine biology. Those of a morphological and systematic character have appeared in the main in the "Arbeiten aus dem zoologisch-zootomischen Institut der Universität von Wien und der zoologischen Station in Trieste. Bd. 1–17 (1878–1908)." With the establishment of the "Verein zur Förderung der naturwissenschaftlichen Erforschung der Adria" in 1903 the activities of the station have been coordinated and directed toward a systematic survey of the Gulf of Trieste along biological and hydrographical lines. (See Cori, 1908.) These investigations are conducted in a carefully located system of stations at four seasons in the year. They include an orderly examination of temperatures at different levels, determinations of specific gravities, transparency of the water, and current measurements, as well as the usual meteorological records. Accompanying this determination of the physical factors of the environment is a systematic examination of the plankton and the shore and bottom fauna. The work is thus essentially a carefully planned biological survey along the lines established in the investigations of the International Commission for the Investigation of the Sea, but applied in this case to a small area. Administrative reports on the progress of this work of the Trieste station appear in the "Jahresberichte" (1–5, 1904–1909) of the Verein, and the results of the survey will shortly appear in a projected quarto series.

The Trieste station is not directly affiliated with the royal or local fisheries administration and is not a fisheries research station, though it receives through the Verein some funds from the budgets of several ministries for the prosecution of its biological survey and includes fisheries problems in its programme of exploration.

A. INVESTIGATOR'S ROOM, WITH AQUARIUM RACK IN FOREGROUND.

B. AQUARIUM ROOM IN BASEMENT.

Photographs from Professor Cori.

INTERIORS OF TRIESTE STATION

The station occupies an irregular quadrilateral plot of ground containing about 1,800 sq. m., situated 150 m. from the present water's edge and 5 m. above sea level. Originally located on the strand, it is now widely separated from the sea by intervening railroad yards. The building is a plain but substantial stone structure of two stories facing the west, with its main axis running north and south. It is of rectangular form (13.3 by 21.5 m.) (figs. 41 and 42), with a long ell (5.18 by 25 m.) facing the walled garden and entrance court. The ground floor (fig. 42) contains corridor and eight rooms, namely, the director's office and laboratory, zoological assistants' laboratory, (Pl. XLIV, *A*), two general zoological laboratories with simple equipment, a physiological laboratory with special apparatus for the study of electrical stimulation, reagent room, and receiving room. The upper floor (fig. 43) contains the library, chemical (with com-

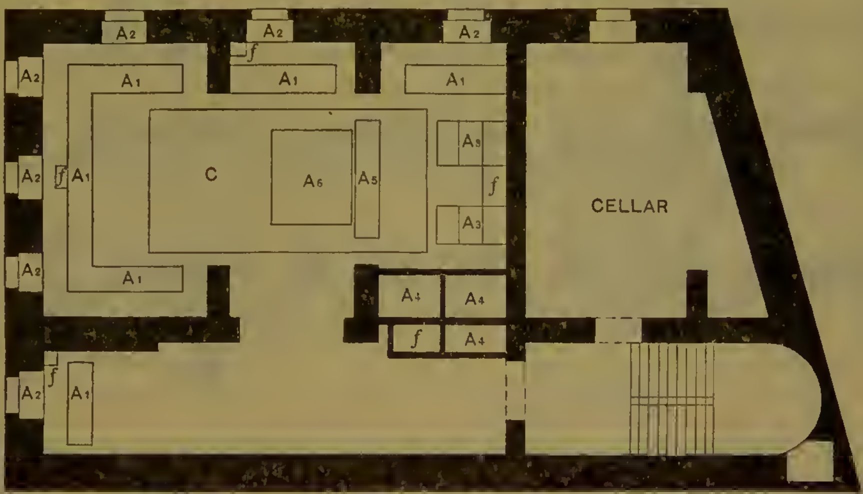


FIG. 41.—Basement with aquaria, zoological station at Trieste. A_1, aquaria of reenforced concrete with 2 glass panes; A_2, cement aquaria on window ledges; A_3, step aquaria of stone slabs; A_4, large aquaria of cement for fish; A_5, wooden aquarium rack; A_6, large wooden tank for fish; C, cement cistern; f, filters. Courtesy of Professor Cori.

plete photographic equipment) laboratory with hood, chemical table and equipment for the simpler lines of work in physiological chemistry, the botanical laboratory with a large collection of algæ in fluids, and an herbarium of over 2,000 sheets representing the local and European marine flora named by eminent specialists, the botanical assistant's laboratory, and three smaller laboratories for investigators. The attic (fig. 44) contains the cistern room, tackle room, and quarters for the scientific assistants, while the basement is given over to the aquaria and storerooms. In the wing of the building are located the engine room, machine shop with lathe, drill, and forge, collection room and shipping room, and the laboratory of the Austrian Malaria Commission, which has its office at the station, and the servants' quarters.

The laboratories are supplied with fresh and salt water and compressed air and are heated and lighted by gas. Their equipment is of the simplest sort and although generally ample the rooms are not always well adapted to the uses to which they must be put.

The recently installed aquaria and circulating system have been erected with great care and represent a high grade of simplicity and efficiency. The water is drawn through a sea pipe 150 m. in length, terminating at the water's edge at low-tide level, then connected with the pump of the *Argo*. The pipe is closed except when pumping

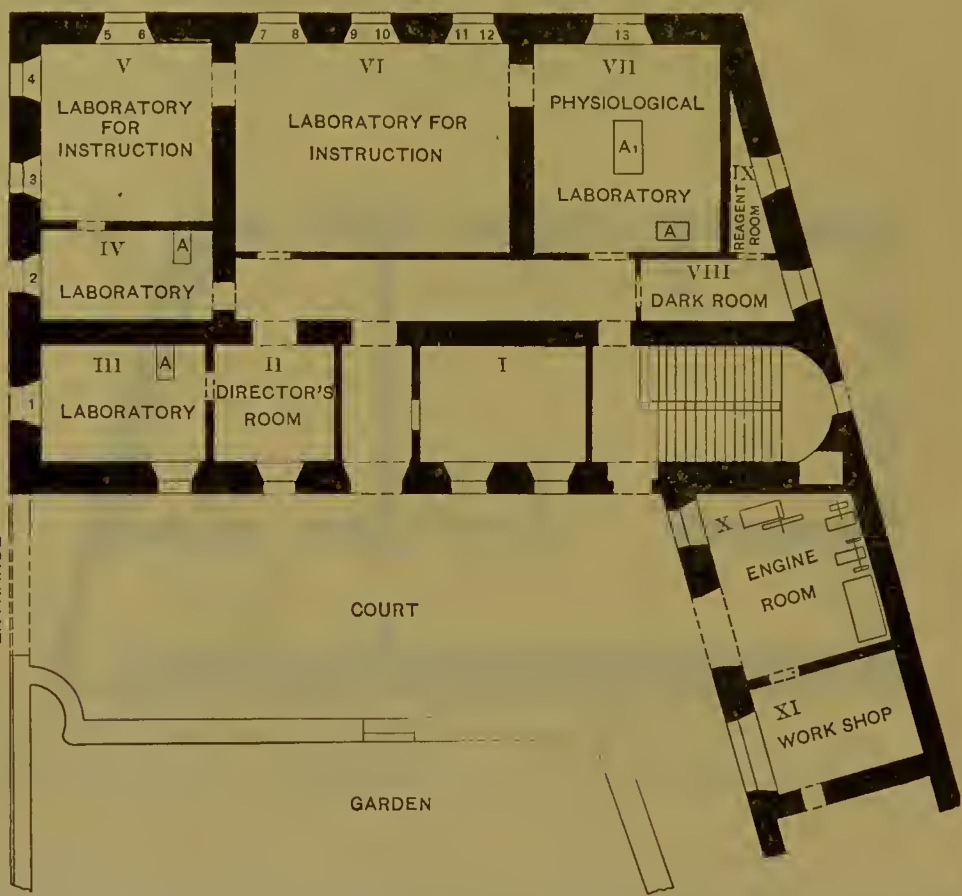


FIG. 42.—Ground or first floor, zoological station at Trieste: *a*, aquarium racks; experimental table with sea water and compressed air. See scale on figs. 43 and 44. Courtesy of Professor Cori.

is in progress. It is 60 mm. in diameter, iron enameled outside and in. The pump is a one-cylinder Weisse and Monsky, bronze lined, with a capacity of 9 cu. m. per hour. It is run by a 4-horsepower Grob gas motor, a 2-horsepower Otto engine having proved too weak to furnish the supply needed. The water is stored in a cement tank (fig. 41, *C*) (4 by 7.5 by 1.2 m.), containing 30 cu. m. beneath the floor of the basement, and in high-level iron tanks in the attic, coated with pitch, containing 12 cu. m. The iron tanks (fig. 44) have not

proved to be satisfactory. The water is used in a closed circulation system and is filtered through sand filters (fig. 41, *f*) after passing through the aquaria before pumping to the high-level tanks. The filters contain quartz sand (1–3 mm. grains) 40 cm. deep. A special reservoir of 5 cu. m. capacity beneath the machine room provides water not in circulation for experimental and shipping purposes. Water is pumped from the sea under favorable conditions of tide and weather and must be renewed at a maximum in three months. The circulating system is of soft lead with 60 mm. mains and branches of 30, 20, and 12 mm. All valves and cocks are of hard rubber.

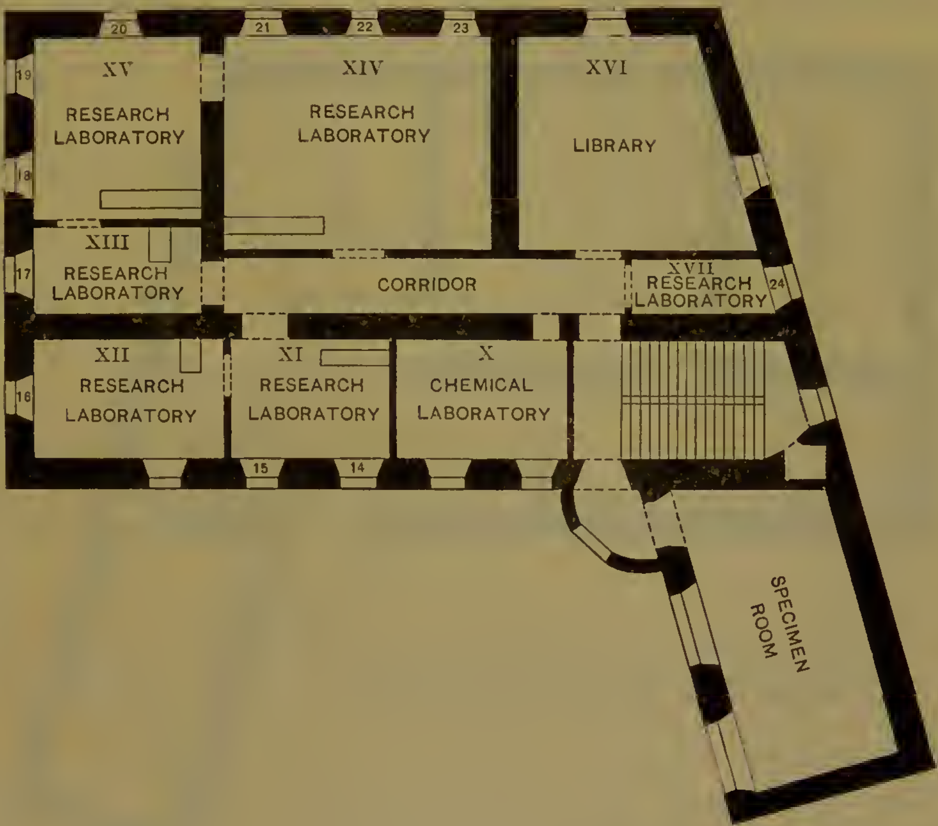


FIG. 43.—Second floor, zoological station at Trieste.

Compressed air is supplied by a Weisse and Monsky compressor of four atmospheres, and is stored in four steel chambers each 80 cm. in diameter and 200 in length and a total capacity of about 4,500 liters. A vacuum apparatus is also attached to the compressor. Before distribution the pressure of the air is reduced to 1.05 atmospheres by passage through a Dräger reducing valve and then passes through a pressure regulator to the distributing system, which is of ordinary gas pipe. The maximum use of air at the station is about 20,000 liters per day. Two hours' use of the compressor suffices to provide this quantity.

The aquaria in the laboratories are only glass containers placed as desired, in aquarium racks (Pl. XLIV, *A*) not unlike those of the Rovigno station. Shallow galvanized iron pans coated with a mixture of coal tar and ship's pitch and dried in heat are used as shelves. An upper shelf (30 by 80 cm.) is placed at a height of 1.5 m. and a lower one (50 by 80 cm.) at a height of 80 cm. The shelves are carried on a simple rack of slat-work and are supplied with salt water and compressed air. The overflow from the aquaria is caught in the pans and carried off by a waste pipe.

The aquaria in the basement are of reenforced concrete, of simple construction, built in situ. There are two large aquaria (fig. 40),

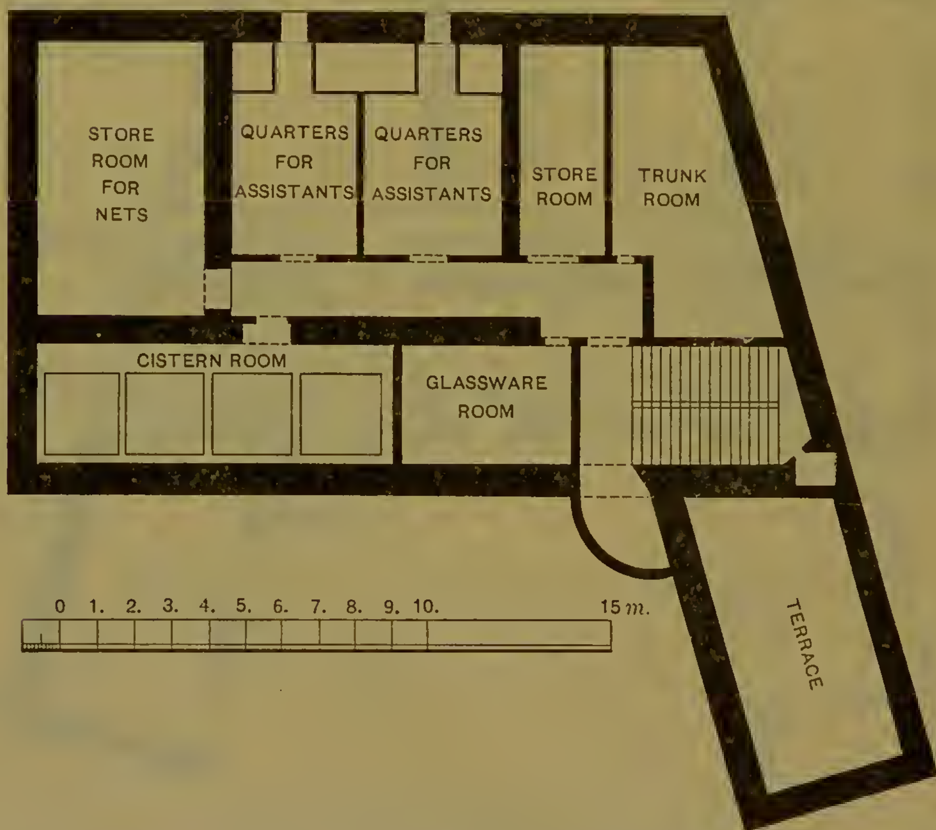


FIG. 44.—Third floor, zoological station at Trieste. Courtesy of Professor Cori.

containing about 0.4 cu. m. A cement table (85 by 165 cm. and 10 cm. thick) rests upon two cement pillars (20 by 75 and 100 cm. high). The cement frame, 78 cm. wide, 156 cm. long, and 60 cm. high, is glazed on four sides with openings on the ends 48 by 58 cm. and on the sides 48 by 124 cm. The walls are 12 cm. in thickness throughout and contain reenforcing metal only in the long horizontal stretches. The lower lintel is 4 cm. wide, the upper 8 cm., the vertical ones on the sides 16 cm., and those on the ends 10 cm. The plate glass, 15 mm. thick, is set in an aquarium cement, made as follows: Dry whiting with boiled linseed oil or linseed varnish is beaten into a thin

putty with a wooden hammer and then thickened to the proper consistency with red lead. No water is used, as in putty, and the materials are very thoroughly mixed by long-continued use of the hammer.

There is also a set of fifteen small connected cement aquaria (fig. 41, a_1, figs. 45, 46, and 47, Pl. XLVI, *B*) of similar construction, each 96 cm. long, 68 cm. wide, and 60 cm. deep with side walls 10 cm. thick and partition walls 12 cm. They are glazed on two sides, the openings being 72 by 60 cm. and the glass 10 mm. in thickness. They stand on a cement table 1.1 m. high with cement supports (*C*) 1 by 0.68 by 0.10 m. and top (*B*) 75 cm. wide and 10 cm. thick, with trough of wood or cement along one side (fig. 46).

The water supply is delivered by an overhead jet entering a vertical canal, 4.5 cm. in diameter, in the end (*A*) and partition (*E*) wall which opens laterally at the bottom into the aquarium. A channel in the cement wall (*O*, fig. 47) adjacent to this receives the glass terminal of the compressed air pipe for aeration. The descending water in the outlet carries with it considerable air, supplying sufficient aeration in most cases. The outlet, as shown in the accompanying sketch (L', L'', L''', fig. 46), is a canal 22 cm. in diameter in the wall of the aquarium rising (L'') from near the bottom to a cross pipe or channel near the top, thence downward (L''') in the wall to the discharge (*P*). The water is thus maintained at a constant level, is drawn off from the bottom, and the vertical pipes can be easily cleaned when clogged through the orifices at *M*. The water enters the siphon through a series of small inlets in the cross pipe L'. In the series of small aquaria the outflow pipes are placed in the partition walls between adjacent aquaria. By closing the descender-pipe the water from the riser-pipe may be passed into the next aquarium at Q. It is possible thus to have individual or serial circulation in the tanks. The partition walls are a few centimeters lower than the others (see G, G′, and E, fig. 45), so that in case of stoppage of outflow pipes of any tank the water merely overflows into the neighboring tanks, over the overflow ledge *H* (fig. 46). This type of aquarium very simply and effectively solves the difficulties of circulation, stoppage, and overflow.

There are also four large floor tanks (fig. 41, A^4) of cement used as aquaria for large animals. The largest one, 1.2 by 1.5 m. and 1 meter in depth, has walls 12 cm. in thickness. Wooden tanks (*A*) 1.45 by 1.6 m. and 0.4 m. deep, with walls 3 cm. thick pitched inside and out, serve a similar purpose. Numerous small aquaria (A^2) upon the window ledges and an out-of-door basin (2.5 by 2.5 and 0.35 m. deep) with glass cover beneath a glass canopy complete the extensive aquarium equipment of this station.

The station has an ample equipment of chemicals and glassware, microtomes, paraffin baths, etc., for biological work, a limited amount

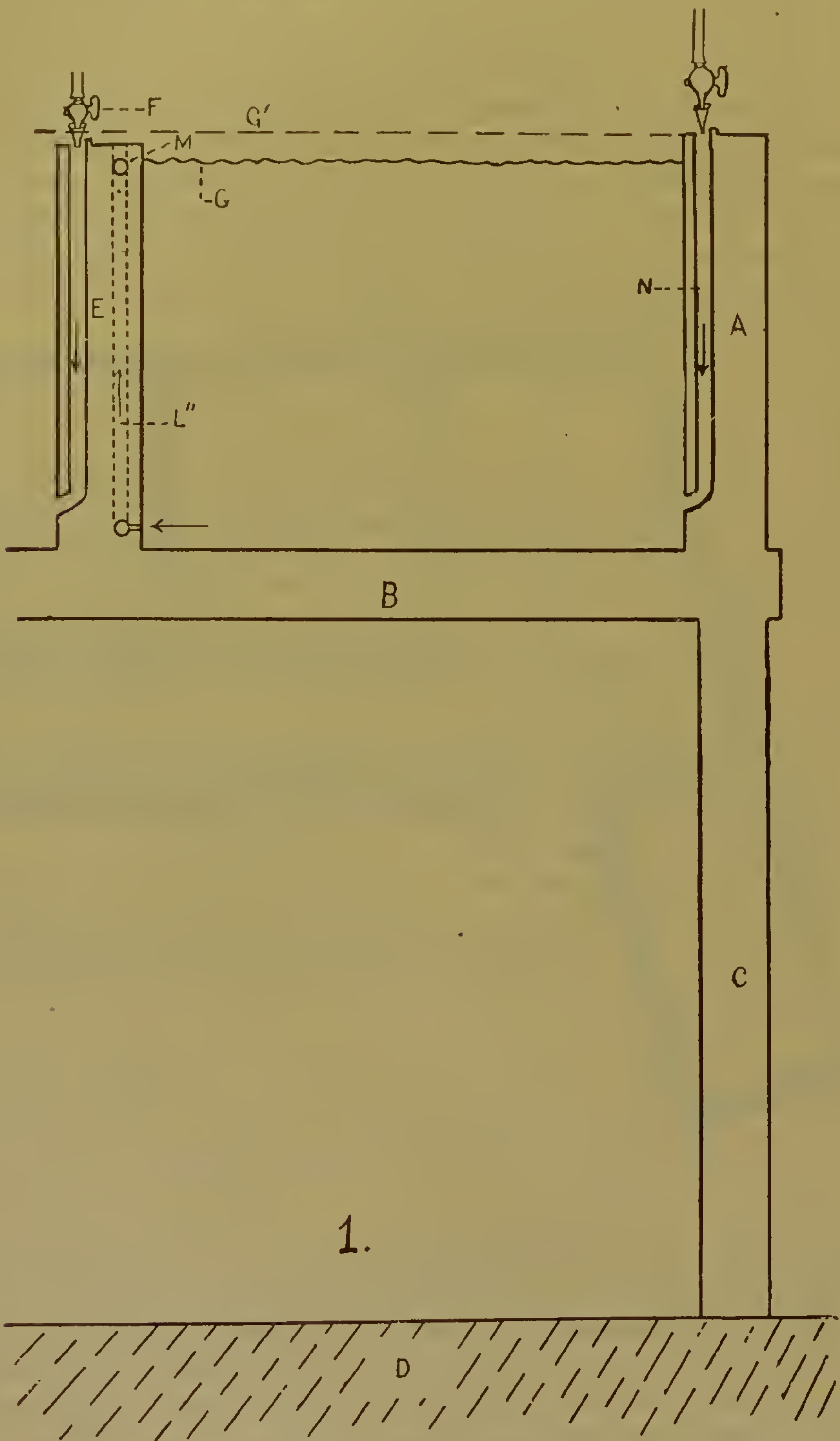


FIG. 45.—Cement aquaria in Trieste station; vertical longitudinal section through end and first intermediate tank.

of physiological and chemical apparatus for work along special lines, an excellent biological library of over 4,000 volumes containing sets

and current numbers of about 25 leading periodicals and over 2,000 bound monographs and reprints, the more important general works and the reports of the Challenger, Valdivia, Plankton, and other expeditions. A collection of dried specimens of the common types of mollusks, echinoderms, hydroids, corals, and seaweeds adorns the corridors and stair landings, and in the collection room is found a large and fairly complete representation of the Adriatic fauna, including an extensive collection exhibiting the seasonal changes in the plankton of the Adriatic.

The marine equipment for field work in biological and oceanographical lines is exceptionally complete and carefully selected. The station possesses, in addition to rowboats and a sailboat, a motor boat, the *Argo*, 9 m. in length, with a draft of 0.7 m. The *Argo* is an open boat with steel hull, and a 12-horsepower 3-cylinder Wolverine benzine motor, with reversible propeller, with fuel tanks in prow and stern, and a 2 m. overdeck at the stern for receiving and sorting the collection. A small mast forward serves for signaling purposes and a light metal framework carries a canvas top for protection against the sun, and canvas sides to shut out heavy seas when needed. A small jolly boat is carried on the after deck, and the reels for sounding and plankton work forward of the engine. Pump and tanks with sea-water circulation provide for transportation of living animals.

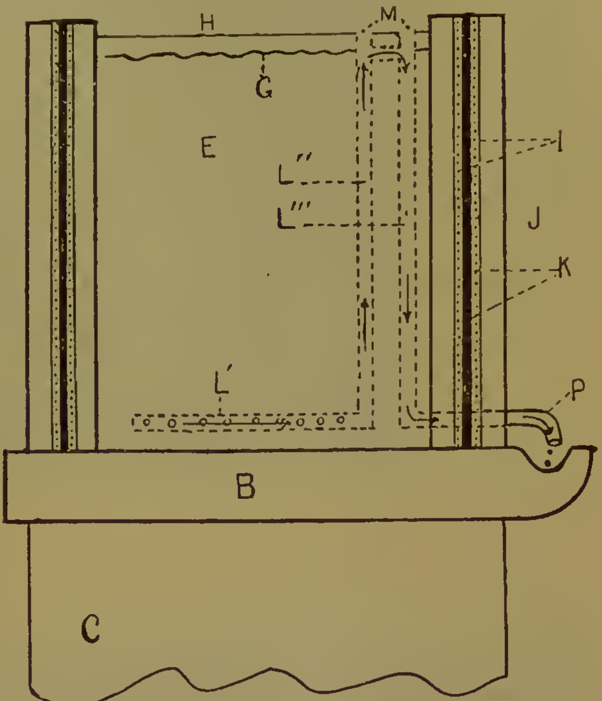


FIG. 46.—Cross section witb projection of partition wall.

Arrows indicate the direction of flow of water; *A*, end of tank; *B*, top of cement table; *C*, table support; *D*, floor; *E*, intermediate partition; *F*, salt water cocks; *G*, water level; *G'*, level of plate glass sides and cement end of series; *H*, overflow ledge from one aquarium to next; *I*, slot in cement plate glass; *J*, plate glass sides; *K*, aquarium cement; *L'*, horizontal section of outlet pipe; *L''*, riser section of outlet pipe; *L'''*, descender section of outlet pipe; *M*, openings into outlet pipe for cleaning; *N*, inlet pipe; *O*, terminal glass tube of aerating apparatus in channel in cement; *P*, discharge into marginal trough of table; *Q*, by-pass for circulation from first tank into second by stopping *L'''*. After sketches furnished by Professor Cori.

The inadequacy of this small boat for the exploration of the Gulf of Trieste and its unsuitableness for work or travel in heavy weather led to the building of a larger boat after several years of careful planning. (See Cori, 1906.) This new boat, the *Adria* (Pl. XLV, *B*), is specially adapted to the work of biological exploration and is admirably equipped with all the mechanical devices needed for the work. All

things considered, it is one of the best boats of its kind at any station in Europe, viz, a small boat to work from a central base of operations with a minimum cost for labor and fuel for short cruises, and yet affording sufficient power for rapid travel and the operation of the necessary machinery of exploration, and the room requisite for scientific operations and the scientific personnel.

The *Adria* is a wooden steamer with coppered hull, with length over all 20.5 m., beam amidships 12 m., depth of 2.4 m., draft of 1.5 m., and tonnage of 44 tons. She is built on the lines of the Norwegian fishing steamers, with low upper works and single mast forward, fishing deck forward, laboratory and cabins amidships, engine room and steering gear aft. She has a 75-horsepower Wolverine motor for benzine, petroleum, or alcohol, makes 9 knots per hour, carries 900 k. of benzine, and has a steaming radius of 450 miles, or fifty hours. She carries a crew of three and has berths for six scientists. Electric

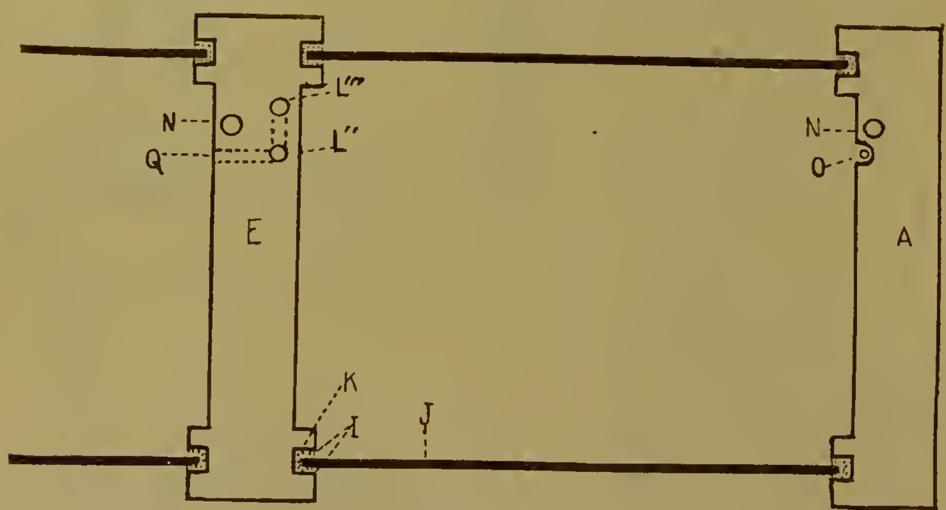
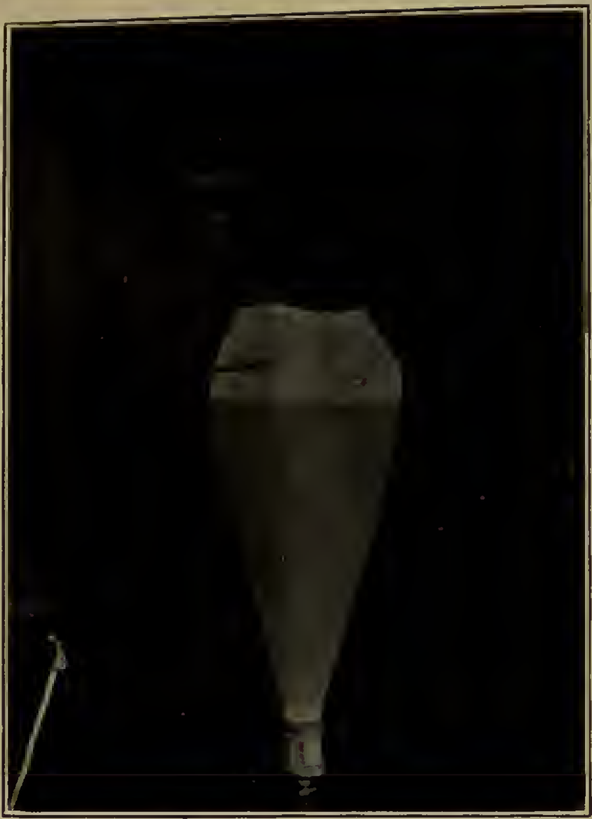


FIG. 47.—Horizontal section.

power from a 2-horsepower accessory gas engine and dynamo serves for the winch, used for dredging, etc., for the air compressor, pumps for sea-water circulation, and for electric lights. The cost of the boat was approximately 60,000 kronen or $12,000. A full description of the boat and its mechanical and scientific equipment will be found in a paper by Professor Cori (1909) in the fifth "Jahresbericht" of the Adria Verein.

The instrumental equipment for marine exploration includes, in addition to the customary instruments for navigation, an optical compass, a Potts mirror-goniometer for quick location of the position of the boat upon the chart, and the hydrographic equipment contains the Ekman current meter and water bottle, Richter thermometers, Assmann aspiration thermometers, and Fuess's slow-acting "Trager" thermometers for use on station buoys and in the study of shore muds and bottom deposits, areometers, and Sechhi disks for recording the transparency of the water. The biological equipment includes, in



A. CORI PLANKTON NET.

B. THE "ADRIA."

TRIESTE STATION.

addition to the usual apparatus for shore collecting and dredges and trawls for bottom work, the Petersen young-fish trawl, the Cori closing net for horizontal towing, and a full line of tow nets and plankton nets. A unique feature in the construction of the plankton nets of the Hensen pattern is the substitution of two parallel bars for each of the two rings at the head of the net. (Pl. XLV, *A*.)

The Gulf of Trieste offers a considerable variety of geographical and physical conditions, giving richness and variety to the fauna and flora. There are rocky coasts with their typical assemblages, and long stretches of flat, sandy beaches rich in the enteropneustan worm, *Ptychodera clavigera*. In the lagoon at Grado are all degrees of transition from salt to fresh water, with wide meadows of *Zostera*. Neighboring salt vats abound in *Artemia salina*. The greater part of the Gulf of Trieste has a bottom of gray ooze, with an abundant fauna of sponges, annelids (*Polygordius*), mollusks, echinoderms, and fishes. *Arca noe* abounds in the shelly banks near the limestone coasts, where calcareous algæ are also abundant and *Amphioxus* is locally common. The pelagic fauna and flora are very rich. Depths are generally 25 to 50 m. and salinity 3.5 to 3.9; winter temperature (surface) falls to 8° C., and the midsummer mean is 16° to 20° C.

The Trieste station offers to the visiting naturalist excellent aquaria and library, a rich fauna, and ample hydrographic and biological field equipment and a seagoing boat.

Literature: Claus (1893), Dean (1894), Sand (1897), Cori (1900, 1900a, 1901, 1902, 1906, 1908a, 1908b, 1908c, 1908d), Fritsch (1901), Jahresberichte (1904–1909).

ZOOLOGICAL STATION OF THE BERLIN AQUARIUM, ROVIGNO, ISTRIA, AUSTRIA.

(Zoologische Station der Berliner Aquarium.)

Scientific director, Dr. Thilo Krumbach, Rovigno.

The Berliner Aquarium, Kommandite Gesellschaft auf Actien, Dr. Otto Hermes director, a corporation which maintains in Berlin an exhibition with extensive marine and fresh-water aquaria, opened at Trieste in 1870 a station for the collection and shipment of marine plants and animals to the distant city. In 1892 the station was removed to Rovigno because of harbor improvements at Trieste, and a permanent building was erected with two rooms equipped for scientific investigation. An addition to the building in 1900 increased the number of places available for research to eight. The establishment at Rovigno represents an expenditure of over 200,000 marks.

Until 1907 the station was in charge of a manager, but in that year a scientific directorship was established and Dr. R. Burckhardt was appointed to the position. Following his death, in January, 1908, the position was taken by the present incumbent, Dr. Thilo Krumbach.

Although the private property of a corporation (passing, however, to the exclusive ownership of Doctor Hermes in 1909), the Rovigno station has been of great service alike to instruction and to research, both within and without the German Empire. It supplies living and preserved material to the German universities at cost and offers its research tables without charge to competent investigators of all nationalities. The long experience of this station in the handling and shipment of living marine animals under the direction of Doctor Hermes and Inspector Hermann Peters has led to a perfection of methods without a parallel among the stations of Europe. During spring and autumn large shipments are made, not only to the commercial aquaria in many continental cities but also to distant universities.

The station receives a yearly subvention of 20,000 marks from the German Government and 1,200 marks from the Prussian State. Two research places are placed at the disposal of German investigators through the ministry of education. The remaining places are open to others on application to Doctor Hermes. There are no fees and no charges for material used in research or for ordinary chemicals or reagents. Glass containers are furnished at cost. The station does not furnish microscopes.

The Rovigno station is entirely under the control of the owner and has no administrative relations to any universities or other educational organizations. Its director is appointed by the company and has immediate charge of all scientific phases of its work and the oversight of its supply department. It provides no facilities for student instruction and has no concern with the fisheries or economic interests other than the exhibition aquaria which it supplies.

The personnel of the station consists, in addition to the scientific director, of a machinist, captain, pilot, fisherman, gardener, and two servants.

Rovigno is a provincial Istrian town, largely peopled by Italian peasants, and offers no accommodations suitable for visiting scientists. The station is accordingly equipped with comfortable living quarters, where pension (board) is provided for all investigators at the station at the moderate rate of 6 kronen per day.

The Rovigno station is located on the Istrian coast of the Adriatic, on the south shore of the Bay of Istria, about four minutes' walk from the local railway station near the eastern end of the town. It is located directly upon Val di Bora, on the water front, 15 m. from the strand and 1.5 m. above mean tide. The building is a stone structure facing north, with its long axis east and west. Triangular grounds to the rear have an area of about 2,500 sq. m. and contain a garden handsomely planted with the Istrian flora.

The main building (10.5 by 30 m.) is three and one-half stories (19 m.) in height, containing in all about fifty rooms. The ground floor contains the passageway to the garden and aquarium (2.5 by 10.5 m.); the office (4.4 by 5 m.), with busts of Darwin, Haeckel, and Virchow; the storage-aquarium room (10.5 by 11 m.), where the animals are kept during preparation for shipment; the lumber room (4 by 5.5 m.); dark room for photographic work; the dining room (4.4 by 9.5 m.); and the kitchen, laundry, and toilet.

The second floor is given over to the scientific work of the station. It contains the quarters, two rooms, of the director; six investigators' laboratories (each 3.4 by 4.5 m.); a chemical room (4 by 4.5 m.), with reagents, thermostat, drying oven, and paraffin bath; an apparatus room (3 by 4.5), with supplies of museum glassware and chemical apparatus, two balances, microtomes, incubators, and drawing apparatus: a collection room (3 by 4.5 m.), containing a collection of types of the local marine fauna, of the local insect fauna, and of microscopical preparations of the Adriatic plankton; a library (3.5 by 9 m.); and toilet. The central corridor opens at the western end upon a terrace (4.5 by 10.5 m.), commanding a fine view across the bay and seaward.

The investigators' laboratories have 3.5 m. ceiling and a single window, and are each equipped with a laboratory desk (1.9 by 0.9 m.), with slides, cupboard, and drawers and shelves at the ends; book shelves; sink with fresh water; an aquarium rack (Pl. XLVI, *A*) (0.5 by 1.1 m.), with salt water and compressed-air supply, with two galvanized-iron trays, the upper 35 cm. wide, the lower 50 cm., each with a removable sheet of ribbed galvanized iron in the bottom of the tray for supporting glass aquaria above the overflow water, which is carried away from the trays by lead piping. The rooms are lighted and heated by gas. Two of the rooms have places for two workers each.

The third floor contains seven sleeping rooms, with accommodations for eight persons, for the use of investigators at the station; toilet, bathroom, and the private quarters of Director Hermes; while the fourth floor is given over to servants' quarters.

On the grounds to the rear of the station are located the machine house (5 by 10 m.), containing salt and fresh water pumps, benzine motor, air compressor of two atmospheres, machine lathe, tool shop, and benzine tanks; the exhibition aquarium house; the water tower; the fresh-water cisterns; and the acetylene plant.

The aquaria and water system of the Rovigno station reflect the results of many years of successful handling of marine animals and the maintenance of a salt-water circulating system, and therefore merit a full description.

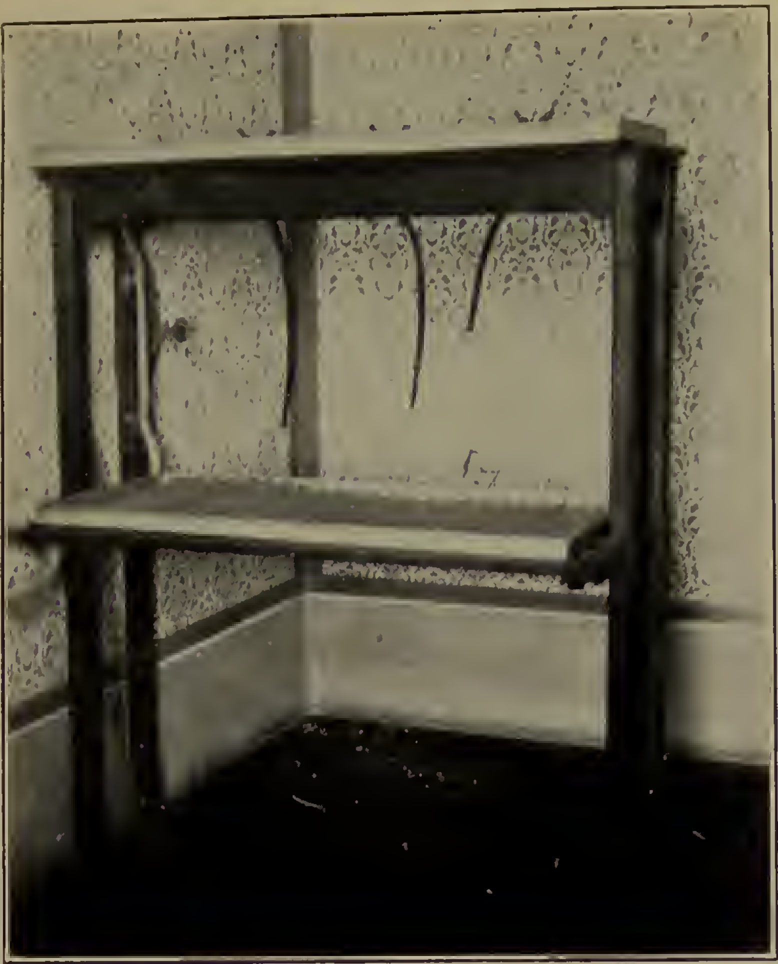
The water in the bay at Rovigno is quite clear and relatively pure. The supply is drawn through a 55 mm. cast-iron sea pipe 60 m. in length, terminating in a strainer at the water's edge at low-tide level.

The pumping plant consists of a 3-horsepower benzine motor, with a supplementary pump attached to the fresh-water circulatory system. The water is pumped to the water tower (5.5 by 6 m.) where it is stored in a tank of stone lined with cement, with walls 40 cm. in thickness. The tank forms the third story of the water tower and has an elevation of 10 m. and a capacity of 27 cu. m. The two lower stories are used as storerooms. A supplementary storage tank (1.85 by 3.8 m. and 1.4 m. high) is placed on the terrace of the building. It has walls of reenforced concrete, Monier system, 4. cm. in thickness.

The circulatory system is entirely of soft-lead piping, with mains of 50 and laterals of 20 mm. diameter, with the occasional use of rubber hose. The valves are of bronze and the terminals of hard rubber, essentially of the type used at the Swedish station at Kristineberg with detachable tips with 0.5, 1, and 1.5 mm. openings.

The aquaria at Rovigno are of two kinds, for exhibition and observation and for storage and culture. The aquaria of the working laboratory are of older types and varied materials. Glass boxes 400 mm. long, 250 wide, and 250 high, as well as glass aquaria of circular type, wooden tubs of circular and oval form, and asphalted wooden tanks 700 mm. square and 380 mm. deep, with 30 mm. walls, and lateral overflow affording depths of water of 270 mm. provide aquaria of movable type. Fixed aquaria of masonry and cement in the form of floor tanks are placed along the walls or in the center of the room. There are fifteen of these, varying in size. Their length ranges from 1.25 to 2 m., their width from 0.75 to 1 m. and their depth from 0.68 to 0.85 m. Their walls in the larger tanks are 25 and in the smaller 15 cm. in thickness. They are fed by overhead sprays, and have outlets in the form of lead matrices set in their floor which receive an outflow pipe of lead, giving the desired depth, usually about 20 cm. The partition walls between the tanks in series are of reenforced concrete 5 cm. thick and are pierced by a series of holes closed by corks, making it possible to maintain a serial circulation when desired, with depths of 20 to 40 cm. Another series of twelve small tanks 470 mm. square and 240 mm. deep, with walls of cement 30 mm. in thickness, in iron frames, is arranged in a series of steps with 90 mm. drop from tank to tank. The water in each tank is maintained at a depth of 210 mm. by the outflow which discharges into the tank below. Along one side of the series is a cement channel through which overflow, in case of stoppage or tanks having independent rather than serial circulation, may be discharged.

The exhibition aquaria are of the latest pattern and are located in a building (5 by 10 m.) formerly used as a greenhouse. The public is



A. AQUARIUM RACK IN INVESTIGATOR'S ROOM.

B. ATTENDANCE CORRIDOR OF EXHIBITION AQUARIA.

BIOLOGICAL STATION AT ROVIGNO.

admitted without charge to the exhibition room. The aquaria in this room, which has been modified to give the grotto effect, are eighteen in number and are arranged in a rectangle with central corridor (Pl. XLVI, *B*) for care and with overhead light. The two larger tanks are 965 mm. long, 650 wide, and 800 deep. The sixteen smaller ones are 650 mm. long, 545 wide, and 700 deep, inside measurements. The larger and smaller tanks have glass of 20 and 12 mm. thickness resting against masonry lips 50 and 100 mm. in width. Their walls are reenforced concrete, Monier system, 40 mm. in thickness, and the tanks stand upon a solid masonry foundation. The tanks are fed through terminals above described, which deliver their spray directly into vertical lead pipes 10 mm. in diameter, set in pairs near the front in the partition walls. The lower ends of the pipes open into the aquarium at the bottom. The descending stream of water carries sufficient air with it in the pipes to suffice for aeration. The elevation of the water tank is 10 m. Terminals with orifices of 0.5 to 1.5 mm. and receiving pipe of 20 mm. are necessary to secure the delivery of aerated water at the bottom of the aquaria 600 to 700 mm. in depth. The outflow at the corner diagonally opposite to that of inflow, passes out through 20 mm. lead pipes set in the wall about 100 mm. below the top, and the waste is carried away in iron pipes. The aquaria here described are simple in construction, relatively inexpensive, efficient in operation and are large enough for the storage and exhibition of most marine animals except the larger fishes and crustaceans.

The transportation of marine animals for long distances has been practiced with success for years by the Rovigno station. Shipments are made in glass jars or in enameled steel cases, made for the purpose, of 20 to 50 liters capacity. The larger cases have a diameter of 50 cm. and a height of 40 cm. At a height of 20 cm. the can is contracted with a sloping shoulder 20 cm. long to a neck 10 cm. high and 25 cm. in diameter. The can is closed with a cork-board lid and incased in a wicker jacket with lid. The cans are shipped in cases 70 cm. square and 50 cm. deep. The glass jars or balloons, used for smaller, and more delicate organisms, are 30 cm. in height, 20 cm. in diameter, and are contracted to a mouth 15 cm. wide. The glass containers are closed with a lid of parchment paper tied about the rim, leaving a small air space below. The glass jars are shipped in compartment cases of wicker work. Some of the secrets of the success attained lie in the great care exercised in the collection of the animals and in their transportation from the sea to the laboratory, to the hardening process in aquaria in which weak and injured individuals are eliminated and food contents and excess of waste products are gotten rid of prior to shipment in reduced quantities of water. No special means of aeration are employed during shipment.

The Rovigno station has an adequate supply of standard chemicals and reagents used in morphological work, is equipped with paraffin bath, microtomes, photomicrographic apparatus and has other photographic equipment of Ziess and Steinheil for marine work. Its marine equipment for field work consists of the *Rudolph Virchow*, a single-screw steamer 15 m. long, 3.5 m. wide, with 90-horsepower engine, capable of making 8 miles per hour; a motor boat the *Hermes*, 7.5 m. long, 1.2 m. wide, with 11.5-horsepower Daimler benzine motor, capable of making 7.5 miles per hour; a sailboat, and a rowboat. The steamer carries a hand winch with 1,200 m. of small steel cable. There is an abundant supply of dredges, trawls, and fish nets, and an otter trawl of small size.

The library of the station, containing several thousand volumes, is exceptionally excellent, including sets of many of the leading zoological journals, reports of expeditions, such as the *Challenger*, *Valdivia*, *Monaco*, and others, important monographs and treatises, a considerable representation of the literature of parasitic diseases (incidental to Schaudinn's celebrated work here upon malaria), and bacteriology, and a small amount of botanical literature. Current numbers of about thirty zoological and botanical journals are received at the station. No publications are issued directly by the station.

The area of station operations extends from Parenzo on the north to Pola on the south. Much of this territory has a depth of 20 to 35 m., a depth of 50 m. being reached at a distance of about 50 miles. The density of the water ranges from 1.028 to 1.030 and its temperature from 10.4° to 14° C. in winter to 24° C. in summer. The tides have usually an amplitude of 0.5 m., but at the maximum in February this is increased to 1.5 m. The shores are rocky and support an abundant fauna and flora. Mud flats are found in the Canal de Leme three-quarters of an hour to the north of Rovigno. Over four hundred species of marine algæ have been determined at Rovigno by Doctors Kuckuck and Lucas. The fauna is essentially similar to that available at the Trieste station.

The Rovigno station possesses the advantages of an excellent library, abundant aquaria, and a rich fauna. Malaria is prevalent in the adjacent campagna but is unknown at the station. The climate is mild, the station being located in a sheltered situation where it escapes the dreaded "bora" of the winter season. Only the months of July and August are oppressive by reason of the heat.

Literature: Hermes (1893, 1895), Schmeil (1893), Sand (1897).

BIOLOGICAL STATION AT LUNZ.

Director, Dr. Hans Kupelweiser, Privat Docent, Zoologisches Institut, Universität, München; Deutschland (September–March), Lunz (April–August).

Telegraph address: Kupelweiser, Lunz.

Acting resident director, Dr. Franz Ruttner. Lunz, Ybbsthalbahn, Oesterreich.

The Lunz fresh-water biological station was opened in the fall of 1905 on the private country estate of Dr. jur. K. Kupelweiser, a resident of Vienna, with Prof. R. Woltereck, of the University of Leipzig, as director and organizer. Under his skillful guidance an excellent equipment along the most modern lines of biological investigation has been installed in a charming Alpine location. In 1908 Dr. H. Kupelweiser took over the directorship of the station.

The station owes its origin and support to the generosity of a single private donor, Dr. K. Kupelweiser, an exceptional instance among German peoples where scientific enterprises are so largely supported directly by the state. Its funds and budget are private but definitely assigned to the foundation and support of a permanent station. In the summer of 1906 a considerable number of European zoologists and botanists were guests at the first formal opening of the fully equipped station.

The station has no relation to educational institutions nor to governmental fishery boards, and gives no instruction. It is exclusively a research enterprise, with its doors open to competent investigators and students of all lands, without fees or charges, and with a hospitality that charms, a freedom from the pressure of economic interests that is refreshing, and an atmosphere of research that is stimulating. The only conditions imposed are those upon students, who are expected to accept as a part of their programme of work some problem suggested by the authorities of the station. Attractive lodgings in the Schloss-Seehof are furnished free to guests of the station and meals may be obtained at a neighboring Alpine "Gasthaus." The station is open throughout the year. Persons wishing to enjoy its privileges should apply in advance to the "Direktor Biologische Station, Lunz." A copy of the regulations governing applicants is sent upon request.

The environment of the Lunz station is not only picturesque and charming but ideal from the biological point of view. Leaving the valley of the Danube at the classic village of Pöchlarn, the railroad (narrow gauge beyond Gaming) winds its way for 64 km. through the foothills into the high "chalk" Alps at Lunz, in the valley of the Ybbs. The station is located at Seehof, about 3 km. beyond the railroad station, on a bit of level ground at the head of Lunzer See (Pl. XLVII, *A*), at an elevation of 617 m. Encircling the little valley with its commanding castle, quaint peasant cottages and blue expanse of the lake are the forest-clad summits of the Fore-Alps, rising to heights of over 1,800 m. and breaking forth here and there in precipitous crags or peaks and plateaus above the green mantle of firs.

The landscape is one of picturesque charm, whether seen under the bright rays of the August sun or under a mantle of glistening snow on a brilliant winter's night.

The surrounding forests and mountain fastnesses constitute a great game preserve and abound in roebuck and chamois, the alpine hare, and the wood and heath cock, while the mountain streams and lakes abound in waterfowl and are planted with saibling, Loch Leven brook, and lake trout from the fish hatcheries of the estate.

The domain of See-hof-Hirschthal, in which the station is located, has an area of approximately 2,500 hectares, and includes within its limits, and thus within control of the station for the purposes of biological investigation, the most of the glaciated watershed of the Seebach, a tributary of the Ybbs, and the greater part of Lunzer See (area 35 hectares, depth 34 m., 200 to 600 m., elevation 617 m.), and Mitter See (150 by 400 m. and 4 m. deep, elevation 750 m.), fed by subterranean springs and free from ice at all seasons, and Obersee (300 by 700 m. and 15 m. deep, elevation 1,177 m.), deeply buried in snow and ice in winter, with an adjacent *Sphagnum* swamp, and numerous small alpine ponds at elevations of 1,400 to 1,800 m., in the high mountain plateaus, with summer water bloom and characteristic fauna and flora. Along the lower course of the Seebach as it enters Lunzer (Unter See) is a series of eighteen ponds (Pl. XLVII, *A*), formerly in the castle gardens, but now used as fish ponds in connection with the hatchery. These are also available for the experimental work of the station. There are in addition thirteen small cement basins (Pl. XLVII, *B*) of about 1 m. depth, of assorted sizes, for use as open-air culture basins. The calcareous nature of the geological formation affords many opportunities for subterranean waters with their peculiar fauna (blind *Niphargus*).

The Lunz station is unique among stations in the range and variety of fresh-water environments under its control, differing in chemical composition, elevation, depth, rate of renewal, relations to currents, and in illumination. Ideal conditions for experimentation in natural environments are here afforded. The possibilities for development of culture basins in natural conditions are unlimited. The fauna and flora, though influenced in character by the near approach of alpine conditions, are not marked by the poverty of high alpine waters. They include a large proportion of species typical for fresh waters generally, and thus afford a normal field for investigation. The papers of Woltereck (1906) and Brehm (1907) give an excellent résumé of the fauna and flora characteristic of the various waters at Lunz.

The lines of investigation carried on at present at the station under subvention are as follows: (1) Determination of local fauna and flora, Crustacea, Rotifera, and subterranean fauna, Dr. V Brehm (Elbogen); (2) variation in Daphnia, Dr. R. Woltereck (Leipzig); (3) distribution and movements of the plankton and the distribution of bacteria, Dr. F. Ruttner (Lunz); Phanerogamic flora,

A. GENERAL VIEW WITH CASTLE IN FOREGROUND AND LUNZER-UNTER-SEE BEYOND.

B. OUT-OF-DOOR CEMENT CULTURE BASINS.

BIOLOGICAL STATION AT LUNZ.

Characeæ and higher algæ, Doctor Knoll (Gratz); hydrography, Doctor Götzinger, Vienna; chemical investigations, Doctor Mulley, Vienna. The plans for future development of the station are comprehensive and reflect the most recent tendencies in modern biology. They include a study in the field of the œcology of fresh-water life, its relation to environment, of variation and heredity in relation to external factors, and of hybridization and pedigree cultures. In the laboratory detailed analyses under control will be attempted of the effects of light, nutrition, and temperatures upon the functions of organisms and studies made of form changes and developmental mechanics.

The station issues no publications, its work appearing in existing specialized journals. It provides material for research at the station but sends out collections only by special arrangement.

The rooms of the station are located in the southwest wing of the castle, the library being lodged in the thick-walled ancient cloisters, dating from 1607 A. D. The ground floor of the central part of this wing contains the working rooms of the station and the floor above the living quarters, while the aquaria and fish hatchery are found in the basement.

Entering the station from the arched passageway into the court, we find ourselves in the library (5.4 by 6.8 m.), whose massive walls and deep windows suggest its ancient origin. Here one finds two work tables at the windows and upon the shelves a rapidly growing library of about 600 volumes and many author's reprints and upon the central table a score of current biological journals. Adjacent to this is the laboratory (5 by 5 m.) of the resident director with two work places. Here is also located the "central plankton collection," including not only collections of the local fauna, but also from other alpine waters, from Germany and Scandinavia. It is one of the aims of the station to maintain a collection where fresh-water types from all lands may be examined by specialists, dealing with groups systematically or with problems of variation. The station is desirous of increasing its already valuable collection. The main laboratory (5.4 by 8 m.) with two more places is amply equipped with tables and cases. Beyond this is the laboratory (3 by 5 m.) of the director, with tables equipped for microscopical and chemical work. An entrance hall (3 by 7 m.) at the rear contains the plankton equipment, the steam and dry air sterilizers, and leads on the one hand to the aquarium in the basement and on the other to the chemical laboratory (4.2 by 5 m.) equipped for inorganic water analysis and for analysis of gases in water. Adjacent to this is a small photographic dark room, used also as glass storeroom. Opening from the hall is a large dark room for photography and for experiments with light. It is equipped with Zeiss microphotographic apparatus, Schott's ultra-violet lamp, mono-

chromatic and colored glasses for experimental work, and dark room, aquaria with full equipment for circulation, aeration and heating (electric). The instrumental equipment of the station includes four microscopes of high grade (guests bring their own instruments), Sartorius' constant temperature apparatus, Schulmeister's electric centrifuge, microtome, balances, and an abundant supply of well selected glassware and a considerable range of chemicals.

The working places are simply but conveniently equipped, and each has a high aquarium shelf across the window with small rectangular aquaria with metal frames and electric heaters for cultures. The building is heated by stoves and supplied throughout with running spring water, electric lights, gas (from Sirius vapor-gas apparatus), and compressed air. In the aquarium cellar (6 by 6 m.) are two large cement aquaria (1.5 by 2 m. and 1 m. deep) glazed on two sides, in front of the windows, and a central aquarium and floor-tank of smaller size, and several step-series of small breeding tanks. The adjacent fish hatchery (9 by 12 m.) is fitted with hatching troughs available for station cultures when not engaged in hatching Salmonidæ.

The most considerable equipment in this line is, however, to be found in the two glass houses (Pl. XLVIII, fig. 48) attached to the dwelling of the resident director at a little distance from the station. These are the warm (Pl. XLVIII, *A;* fig. 48, *A*) and cold (Pl. XLVIII, *B;* fig. 48, B) houses with adjacent heating plant. They are substantial structures of cement, steel, and glass, in the form of a modern greenhouse, each 5.5 by 10.5 m., and glazed throughout. One end of the cold house has a small room which is equipped with two work tables. In each room there is a peripheral row of connected aquaria made of reenforced concrete 0.41 to 1.28 m. in width, 0.35 m. in depth, and 1.05 m. (top) from the floor. There is also an adjustable gravel slope (2.25 by 0.24 by 0.07 m.) (fig. 48, *C*), with running water for brook cultures of *Planaria alpina* and other organisms of mountain streams.

To the rear of the marginal aquaria and also above them is a running slat shelf for potted plants and small aquaria. In the center of each house is a subcircular cement floor tank (2.5 m. in diameter) for water plants, with walls 10 cm. thick and rising to a height of 70 cm. The walls are slotted for subdivision of the tank if desired. Beyond the large tank is an elongated floor tank (1.57 by 4.1 m., depths 40 and 69 cm. in the warm house; 1.38 by 1.83 m. in the cold house), with walls 10 cm. thick and 58 cm. in height. Above these tanks (Pl. XLVIII) are superposed metal racks for plants and small culture basins.

These houses add greatly to the facilities of the station for experimental culture under control of the local fishes, amphibians, and

A. INTERIOR OF HOTHOUSE, SHOWING FLOOR BASINS AND MARGINAL AQUARIA.

B. INTERIOR OF COLDHOUSE, SHOWING MARGINAL AQUARIA, FLOOR, TANK, AND RACK.

CULTURE HOUSES AT LUNZ.

invertebrates in the cold house, and of tropical forms in the warm house (winter temperature, 17° to 20°; summer, 20° to 35° C.). In the latter are not only thriving cultures of tropical water plants, but a number of species of tropical fishes (Cyprinidæ, Cyprinodontidæ, Labyrinthidæ) breeding abundantly.

The field equipment of the station includes the usual nets and dredges for shore and bottom collecting and bacteriological and hydrographical explorations. Small boats are placed on the several lakes, and at Ober-See a hunter's hut is equipped with chemicals, glassware, nets, and a microscope, with beds and cooking utensils for field parties working at night or for some days at the greater eleva-

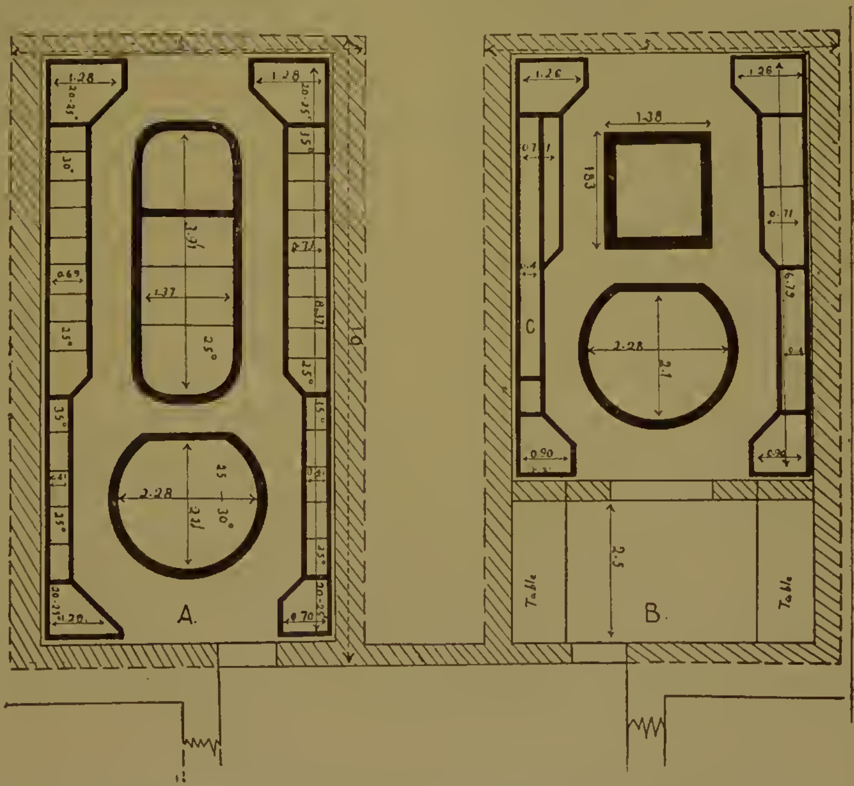


FIG. 48.—Plans of culture houses, Lunz station; *A*, hot house; *B*, cold house; *C*, trough for artificial brook.

tions. On Lunzer-See is a large scow boat (2 by 6 m.) with glass bottom, overhead awning, plankton pump and winch, for field observations and collecting operations.

The Lunz station is admirably located and superbly equipped for a systematic attack in the fresh-water environment upon the problems of heredity variation and adaptation from the causal standpoint. It is to be hoped that the preliminary inventory of the fauna and flora and the determination of the physical constants of the environment may soon pave the way for the beginning of the work upon the more serious problems of the station's programme. The charm of the place, the freedom of the organization from embarrassing alliances with

economic aims, and the excellent equipment should attract many biologists to cooperate in the enterprise.

Literature: Woltereck (1906, 1908), Kuckuck (1906), Brahm (1907), Zschokke (1907, 1907a).

FISHERIES EXPERIMENT STATION IN VIENNA.

Director, Dr. E. Neresheimer, Abth. VII, Fischereiwesen, K. K. landwirthschaftliche-chemische Versuchsstation in Wien, II/1 Trunnerstrasse Nr. 3.

Pathologist, Prof. Dr. J. Fiebiger, Tierärtzliche Hochschule, Wien.

Assistant in chemistry, Dr. J. Wittmann.

Assistant in zoology, Dr. O. Haempel.

This division of the experiment station was opened in 1906 primarily for the chemical investigation of foods used in fish culture. Its work was enlarged in 1908 and Professor Fiebiger was made director. In January, 1909, Doctor Neresheimer, formerly of the Munich station, was called to the directorship and Professor Fiebiger continues his services as pathologist.

The field of operations of the station is essentially like that of Professor Hofer's institution at Munich. It is a central bureau dealing with problems of pollutions of streams and lakes by municipal and industrial wastes in their relation to problems of the fisheries and public uses and interests, for the whole of Austria. The lines of work in progress are investigations on the relationships of fresh-water fishes by the serum method, age determinations of food fishes, studies in the biology of fish parasites, especially Protozoa, comparative studies on the effects of alkalies, salts, and acids on the lower forms of life in fresh water, the function of the swim bladder in the eel and in coregonid fishes, and plankton investigations in Austrian waters.

The station is lodged in the building with the agricultural-chemical experiment station at Vienna where it has two biological and two chemical laboratories and an aquarium room with twelve culture aquaria.

BIOLOGICAL STATION IN HIRSCHBERG, BOHEMIA.

Director, Prof. Dr. R. v. Lendenfeld, Zoologisches Institut, Deutsche Universität, Prag, Bohemia.

The Society for the Advancement of German Science, Art, and Literature in Bohemia has since 1906 granted a small subvention for the prosecution of biological investigations in the Hirschberg Grossteich about 100 km. by rail north of Prague in the domain of Graf v. Waldstein, who has granted the use of the lake and a small house for the purposes of a laboratory. The investigations planned include a geological, chemical, hydrographical, bacteriological, botanical, and zoological exploration of this body of water. This work is carried on in connection with the various scientific departments of the German University at Prague.

BOHEMIAN FRESH-WATER STATION.

Director, Prof. Dr. Anton Fritsch, Bohemian University, Prague, Bohemia.

In 1864 a committee was formed in Bohemia to conduct a scientific survey of that country. One of the problems set before the zoological section was the investigation of the life in lakes, ponds, and streams. In 1871 the systematic investigation of the distribution of organisms in the lakes of the Bohemian Forest was begun by Professor Fritsch and has been continued down to the present time by him and his assistants in various Bohemian ponds and lakes and in the Elbe. The results of this work have appeared in various papers in the "Archiv für Landesdurchforschung Böhmens" (Bd. 1–14, 1869–1909). This pioneer work was carried on with no, or at the most small, subvention from public or private sources. The first systematic study of the vertical distribution of the plankton in lakes was made by Professor Fritsch in 1888 in these investigations. In that year a gift of a movable building for the station was made to the committee by a friend of the enterprise. This building was a wooden structure of eighty detachable parts and a total weight of 1,000 kg. It is of rectangular form with 12 sq. m. floor space, two windows, and two work places. The roof is made of ten waterproofed sheets of canvas in interlocking frames, and the sides of paneled wooden sections dovetailing together and held in place by the timbers of the floor and the frame at the eaves. The window shutters fold down as work tables. It can be taken down and reerected in a few hours. This station has been moved about to various lakes in Bohemia, to Unter-Počernicer and Gatterschlager lakes and is still in use as a portable field station investigating the local fauna and flora and the food of the carp.

In 1892 a small permanent building for the station was erected as a gift by Baron Dercsényi on Unter-Počernicer Lake, 15 km. east of Prague on two small tributaries of the Moldau. The lake is an artificial carp-pond produced by damming the streams. It has an area of about 30 acres, is 2 to 3 m. in depth, and lies at an elevation of 220 m. above the sea. It has high summer temperatures (24° C.) and a rich fauna and flora (Fritsch u. Vavra, 1894).

The station building is a single one-story stone structure of 18 sq. m. containing the laboratory (12 sq. m.) and living room (6 sq. m.). Descriptions of the simple apparatus and methods used at this station will be found in the papers of the director.

Literature: Fritsch (1889, 1891), Fritsch u. Vavra (1894).

FRAUENBERG POND CULTURE EXPERIMENT STATION.

Director, Herr Wenzel Šůsta, Teichwirtschaftliche Versuchsanstalt, Frauenberg, Böhmen, Oesterreich.

This fisheries station is located in southern Bohemia, west of Frauenberg, near the railroad station Nakri and the village Divčic. It was opened in 1906 by the generosity of Prince Adolf of Schwarzenberg, with the cooperation of the Austrian Fisheries Society, in a region where carp culture has been carried on for three hundred years. In 1908 a series of twelve experimental ponds were constructed here in the center of a region abounding in natural and artificial carp-ponds under culture. In connection with the experimental work Dr. P. Kammerer, of the biological experiment station in Vienna, has carried on some scientific investigations of the fauna and flora of the ponds (1907), and Dr. J. Wittmann, of the agricultural experiment station in Vienna, has conducted some chemical work upon the composition of pond waters, bottom soils, carp foods, and pond fertilizers. and the flesh of the carp.

The results of the scientific investigations carried on here have appeared in the "Mitteilungen der Teichwirtschaftlichen Versuchsanstalt in Frauenberg, Böhmen" (1907+).

Literature: Šůsta (1906), Kammerer (1906–7, 1907).

ROYAL HUNGARIAN MARINE BIOLOGICAL STATION.

Director, Mr. Viktor Garády, Magyar Királyi biologiai Állomás, Fiume (Croatia), Hungary.

This station was founded in 1905 by the ministry of commerce as a collecting and supply station for Hungarian educational institutions. It has no direct affiliation with educational institutions, but its limited facilities are utilized by Hungarian biologists for purposes of investigation. It is located in the Marine Building (Palast der Marine Behörde) on the water front. It occupies four rooms on the ground floor, in all about 150 sq. m., including a preparation room (2.3 by 10.2 m.) well lighted, with small aquarium, work tables, and collections; a machine room (2.3 by 2.3 m.) containing the pumping plant; a large well-lighted aquarium room (5.7 by 10.94 m.) containing cement aquaria of three sizes in three series, 5, 10, and 15 in number, respectively. They are glazed on two sides and are constructed somewhat after the Trieste system. The circulating system (after the Rovigno model) is of lead with hard-rubber fittings. Adjacent to the aquarium room is the laboratory with a single working place.

Plans are made to double the space available for the work of the station in the near future, providing for a number of laboratories for investigators. The station is provided with a small steamer, the *Klotild*, with a simple outfit of nets and dredges for field work.

The investigations carried on at the stations are published mainly in the "Contributions from the Hungarian Zoological and Botanical Societies (Állattani Közlemények and Botanikai Közlemények) of Budapest.

The fauna and flora in the Gulf of Quaernero are proverbially rich and the locality is classic as the hunting ground of many naturalists, especially prior to the establishment of marine stations elsewhere. A brief résumé of the striking features of the local fauna will be found in the paper of Lajos (1908).

Literature: Lajos (1908).

ROYAL HUNGARIAN BIOLOGICAL STATION FOR FISHERIES AND FOR PURIFICATION OF SEWAGE.

(Magyar Királyi Halelettani és Szennyviztisztito Kiserleti Állomás, Budapest.)

Director, Dr. M. Korbuly.
Chemists, A. Lindemeyer, J. Halmi, P. de Jekelfalussy.
Biologists, Dr. R. Mancha, E. Unger.
Clerk, Count L. Königsegg.

The great system of water courses in Hungary has been the basis from ancient times of one of the most extensive fresh-water fisheries in Europe. The development of engineering works in the interests of navigation and flood control commenced in the eighteenth century, and the rapid growth in recent years of paper and beet-sugar factories, petroleum refineries, and other industrial enterprises involving injurious chemical wastes, together with the uncontrolled discharge of municipal sewage in streams, have resulted in greatly diminishing the former abundance of fish in Hungarian waters.

It was not until the latter part of the nineteenth century that systematic efforts at a rational, scientific control of the fisheries was made, first, by the investigation of the Royal Hungarian Society of Natural Sciences, and later, in 1884, by the establishment by the Government of a superintendency of the fisheries and the passage in 1888 of a fishery law which made possible the legal control of the fisheries and permitted their economic development and resulted in the formation of many fisheries companies. In 1896 the fisheries superintendency was combined with the Royal Hungarian agricultural department as a special section, to which belonged not only the economic but also the scientific control of the fisheries, with Mr. John Landgraf, the superintendent since 1888, at its head.

In 1906 the fisheries section was divided into two coordinate offices, (1) the superintendency of fisheries noted above, with Mr. N. Repassy, engineering councillor, at its head, having as its functions the control of natural and artificial fisheries, the enforcement of the fisheries law, and advisory duties in matters of fish culture; (2) the biological sta-

tion, whose statutes of organization assign to it the following functions and duties:

1. Investigations into the physiology and biology of fresh-water fishes and crawfish, and of organisms, both vegetable and animal, which make the natural food of fishes and crawfish.

2. To study the value of artificial foods used in fish ponds, by methodical experiments.

3. To determine and to increase the value of fish ponds.

4. Investigations into the poisonous influence of organic and inorganic substances, dangerous to useful animals living in fresh water.

5. To determine the causes, the measure, and the extent of destruction of fish due to contamination of water.

6. To study the different methods for purification of sewage and sewage disposal, at home and abroad, and to pay attention to the results obtained by means of different methods, and to give evidence and advice to legal authorities, companies, and private persons on every question of this kind.

7. To inquire, also unexpectedly, into industrial establishments and factories causing pollution of water, in order to ascertain whether they have done their duty as to the purification of sewage.

8. To deal also with diseases of fishes and crawfish when the malady originates in physical or chemical causes and results in destruction of the animals in large numbers.

The evidence and advice given by the station are gratuitous if it is possible to give evidence without any special investigation or if the question is of public importance.

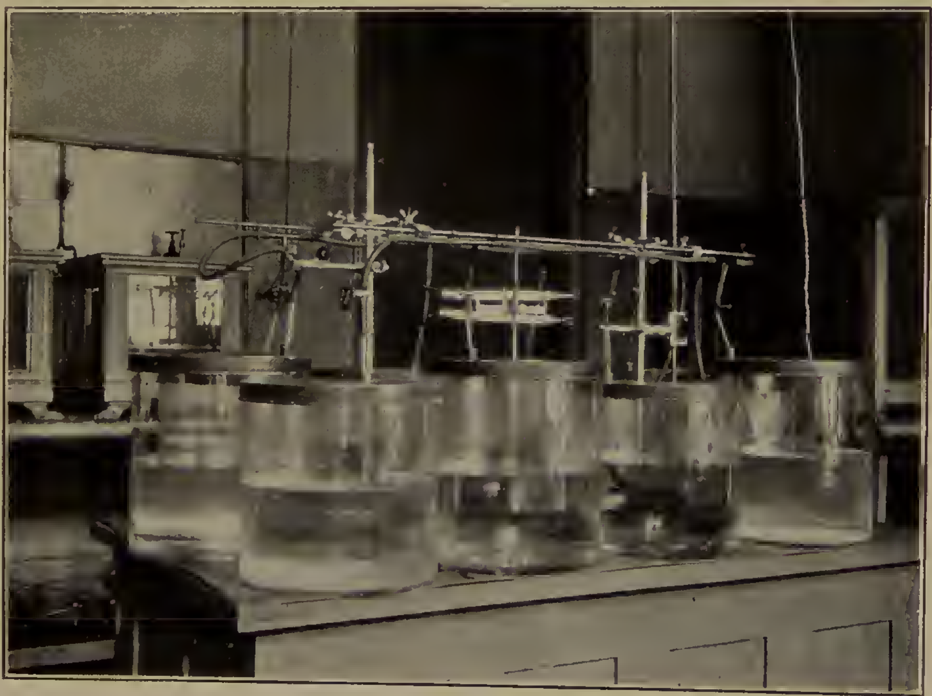
Chemical analyses and investigations of a biological character generally must be paid for, and the fees belong to the treasury of the state.

Organized in 1906 with but a single member, the director, upon its staff, the work of the station increased so rapidly in the three years following that three chemists and two biologists are required to conduct its investigations.

The budget of the fisheries section for 1909 was 242,555 kronen ($48,511), increased from 77,960 kronen ($15,592) in 1899. Of this sum the station received 43,440 kronen, expended for equipment (5,000), salaries (18,040), rental (6,000), upkeep (9,000), and travel (4,400).

The station is purely one for research along applied and technical lines and is of great importance both to the fisheries and the industrial interests involved and to municipalities and corporations and private parties confronted with the problems of sewage disposal and the preservation of the purity of natural water courses. The lines of investigation pursued are well illustrated in the subjoined tabular statements:

A. LARGE AQUARIA.



B. STINK-AQUARIA WITH AERATION.

BUDAPEST FISHERIES LABORATORY.

	1906 (staff, 1 person).	1907 (staff, 4 persons).	1908 (staff, 7 persons).
Cases decided	290	561	561
Chemical analyses		250	252
Biological investigations			247
Physiological experiments			169
Furnished evidence	14	105	34
Number of days spent in working abroad by different persons of the staff		154	169
Fees paid for evidences ... kronen		1,800	1,960
Fees paid for analyses, etc ... do		17,134	13,330

Special investigations of the station.—Studying the problem of purification of sugar-factory wastes in 1906; in 1908, physiological experiments with fishes and wastes of different kinds and in solutions of poisonous substances.

Physiological experiments made by the station in 1908.

Solutions of different concentrations.	No. of experiments.
Waste from 8 sulphite-cellulose factories	58
Sulphurous acid	15
NaHSO, CaH (SO), etc	19
Waste from hemp and flax preparing	[illegible]4
Butyric acid	10
Wood distillery	10
Waste from a petroleum refining factory	2
Waste from a tannin factory	2
Water of "Lake Palics"	
Total	169

The duration of these experiments was from one to sixteen days.

A series of annual reports was established in 1909.

No formal instruction is given in connection with the institution, though, as the tables above show, it is much occupied with the dissemination of information and expert advice. No regular provision is made for the conduct of research by independent investigators in the laboratories, but such are welcomed and are admitted on notification to the royal Hungarian minister of agriculture.

The station is at present housed in rented quarters on the fourth floor at Aréna ut 29.

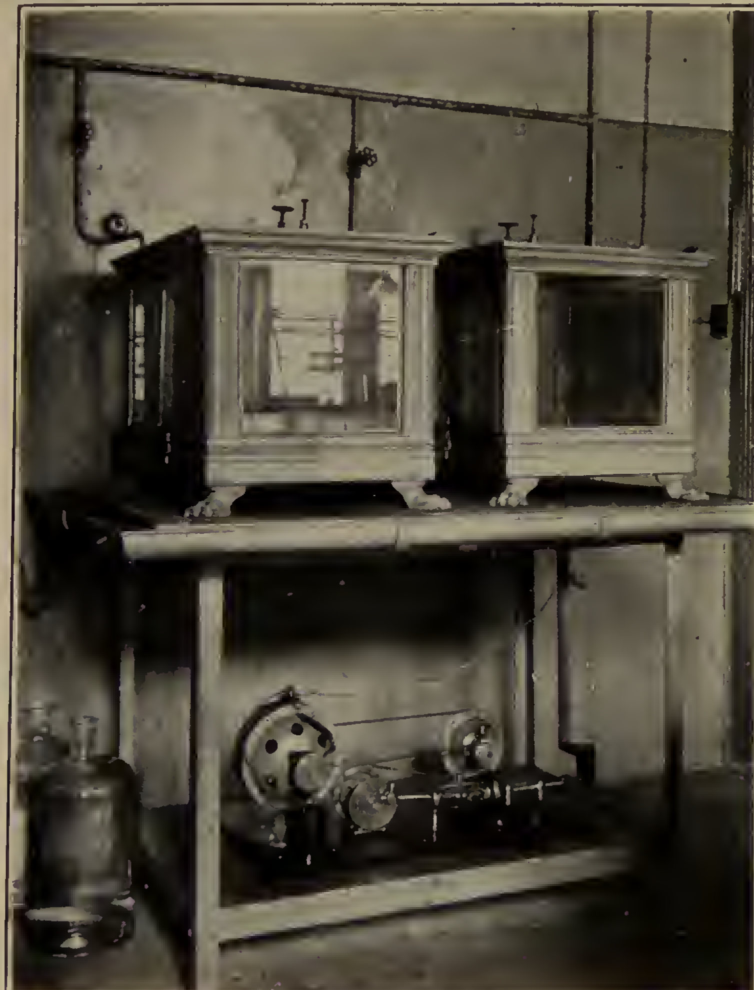
The quarters consist of the director's office, two chemical laboratories, a biological laboratory, balance room, dark room, instrument room, distillation room, etc. The chemical laboratories are equipped for quantitative and qualitative analysis of organic and inorganic substances, and the biological laboratory has two large (104 by 64 cm. and 74 cm. high; Pl. XLIX, *A*) and four small (64 by 44 cm. and 45 cm. high) aquaria (Pl. L, *A*) for experimental work with fishes, and sixteen cylindrical glass aquaria (Pl. XLIX, *B*) for the study of polluted waters.

The aquaria for fishes rest on tables (90 by 130 cm. and 85 cm. high) with angle-iron frames, with cement tops covered with lino-

leum, with marginal gutter and trapped waste pipe. The aquaria have heavy cast-iron frames with plate-glass windows, metal cover, and are supplied with aqueduct water under pressure which at the same time provides the necessary aeration. In case of cessation of the water supply and decline of the pressure, a spring (Pl. L, *A*), fitted upon the water pipe on the wall, is automatically released and makes automatically an electric contact which sets in operation an electrically driven air pump located on the shelf beneath the aquaria. Air is piped from the pump to the different aquaria dependent upon the water pressure. Renewal of the pressure automatically breaks off the electric contact and stops the pump.

The aquaria for the study of polluted waters have no water circulation and are aerated by an electrically driven pump. (Pl. L, *B*.) They are provided with close-fitting metal covers and with tubulation for the admission of the air pipe.

The biological laboratory is supplied with two high-grade Zeiss microscopes and accessories, and is equipped for microphotography. The station has a library of 560 volumes pertaining to its lines of investigation.



A. SMALL AQUARIA WITH AUTOMATIC AIR PUMP.

B. AIR PUMP FOR STINK-AQUARIA.

BUDAPEST FISHERIES LABORATORY.

CHAPTER VII.

SCANDINAVIA.

Norway with its thousands of miles of seacoast, its extensive maritime trade, its great fisheries, its sheltered fiords, and its enterprising people might well be expected to be the home of biological stations. Though there is but a single university in the land there are three well equipped marine stations, at Bergen (1891), Dröbak (1894), and Trondhjem (1900), respectively, and a fisheries bureau actively engaged in marine research. The popular interest in the fisheries has played an important part in furnishing a basis for the existence of the stations, but the economic factor has had little to do with their organization and administration, save at Trondhjem, where a plaice and trout hatchery is combined with the station. The sea-fish hatchery at Flödevig (1882) has no formal biological station attached to it. The central laboratory of the International Commission for the Investigation of the Sea (1902) was discontinued in 1908.

The funds for the establishment of the Norwegian stations have been derived in the main from the profits of the state liquor business or braendevinssamlag, supplemented by many minor gifts from savings banks and public-spirited citizens. Their upkeep is drawn, in part, from the same sources and from the funds of scientific organizations and the cultus ministerium.

The Swedish marine biological station interests have, from the first, all been concentrated in one station at Kristineberg (1877), controlled by the Academy of Sciences, supplemented in recent years, in hydrographical lines, by Professor Pettersson's station hard by, at Bornö. It was not until 1909 that a formal fresh-water station was opened in Sweden, at Aneboda.

The location of Copenhagen upon an island and the easy access to Baltic shores and waters has made unnecessary any formal marine research station in connection with the University of Copenhagen. The fisheries interests, however, in 1889 opened a scientific bureau with a biological station for fisheries investigations connected therewith, now located at Nyborg. A fresh-water station, first opened in 1898 as a summer research station, has become one of the most productive centers of investigations in limnology in Europe, though

its material equipment is meager.' The large Danish interests in the fisheries, especially about Iceland, led Denmark in 1902 to take a prominent part in the work of the International Commission for the Investigation of the Sea, and her neutral territory and central location made Copenhagen the natural choice for the location of the central bureau of this international commission.

BIOLOGICAL STATION AT BERGEN.

Director, Candidat Bjorn Helland-Hansen.
Collector and preparator, Nils Glimme.
Telegraph address: Biologen, Bergen.

The biological station at Bergen owes its origin largely to the efforts of Prof. Fr. Nansen and Dr. J. Brunchorst. A legacy of $100 to found a marine aquarium, from a physician, Wilhelm Martens, led to the establishment by Nansen, then director of the Bergen Museum, of several small aquaria in the building. The popular interest aroused by these led Professor Mohn at the banquet held at Bergen in honor of the Norwegian North Atlantic Expedition, to urge the establishment of an aquarium. Later Doctor Nansen upon his return from Naples took up the matter and secured from "Det nyttige Selskab" a grant of 1,000 kronen for a zoological station at Bergen. The agitation for a zoological garden in the new Nygaardsparken, in 1890, gave an occasion for Doctor Brunchorst to continue the propaganda for an aquarium, seal park, and biological station, a movement which culminated in that year, at the banquet in honor of the sixtieth anniversary of Dr. D. C. Danielssen, director of the museum, in a subscription of 10,000 kronen for the station. In the following year the movement at Christiania for the foundation of the station at Dröbak led the citizens of Bergen to increase their gifts for the Bergen station to 24,000 kronen. Grants from societies and institutions increased the amount to 40,000 kronen. The aquaria and seal park were formally opened to the public on November 6, 1891, and the station was completed at a cost of 52,000 kronen for the whole plant. It was occupied early in the following year with Doctor Brunchorst as director. He was succeeded in 1901 by Dr. O. Nordgaard, who continued at the post till 1906, when it was taken by Mr. B. Helland-Hansen, the present director.

The staff of the Bergen station consists of the director and temporary assistants employed from time to time in chemical, hydrographical, and biological work, a collector and keeper, and a boy. The collector and preparator, Nils Glimme, has been with the station since its foundation and is favorably known to many zoologists as the Lo Bianco of the north.

The organization and administration, as well as the history of the station, are closely interwoven with that of the Bergen Museum.

The station as a scientific organization is a quasi branch of the museum, housed in a building built by private subscription on land belonging to a private park. The title to the buildings resides in the museum, but the city of Bergen provides annually for the repairs and improvements on the buildings and grounds. The director of the station is appointed by the board of directors of the museum with the approval of the minister of education. This board of directors consists of ten members, two appointed by the Norwegian Government, and the remainder elected by the large membership of the Bergen Museum Association. The affairs of the station are managed solely by the director working in consultation with a committee of three appointed from the directors of the museum. This highly centralized form of organization affords abundant room for the initiative of the administration and provides for a continuous policy with at the same time responsibility to and consultation with a superior advisory body represented by but few members.

The station has no endowment. The budget for 1907 was as follows:

Receipts and expenditures, Bergen biological station, 1907.

RECEIPTS.

	Kronen.
Income for station purposes:	
From the state	5,500.00
From the museum	989.02
Sale of material and rent of tables	901.92
Special grant from museum for fiord investigations	1,500.00
Total	8,890.94

EXPENDITURES.

Salaries	4,183.35
Upkeep	2,521.34
Deficit from previous year	2,983.35
Total	7,688.04

Receipts and expenditures for aquarium and seal park.

RECEIPTS.

	Kronen.
Admissions	1,442.91
Contribution from Friendly Society	500.00
Contribution from museum	3,351.61
Total	5,294.52

EXPENDITURES.

Upkeep, food, and attendance	1,786.10
Deficit from previous years	3,310.82
Interest	40.79
Cash	156.81
Total	5,294.52

The station is located on Puddifiord, a small branch of Byfiord, a little over a mile from the market, and is easily reached from the quays by electric tram. It is situated at the edge of Nygaardspark, adjacent to the navy-yard, on a small flat just above tide level, and is about 70 m. from the water's edge. Its grounds contain 3,789 sq. m. and include, beside the station building, an irregular seal pond and a one-story workshop and store building 5.3 by 19.5 m. The Bergen station (Pl. LI, *A*) is a two and one-half story wooden building 12 by 30 meters, on foundations 0.5 m. above high water. Its main axis runs southeast and northwest. The first floor contains the vestibule and the public aquarium room (5.5 by 10 m.), pump room, and the receiving and sorting room.

The aquarium room is lighted only through the aquaria, giving a grotto effect. The tanks are arranged upon three sides of the room; three and five large ones, respectively, upon the sides and four smaller ones at the end. The floor and sides of the large aquaria are of solid masonry laid up in cement. The tanks are of several sizes. The two largest ones are centrally located on either side and have a length of 4 and 3.5 m., respectively, and a width of 2.75 m. The lateral ones upon the south are 2.6 by 2 m. and the four smaller ones upon the south 1.3 by 1.5 m., respectively. The depth of the water is 1.1 m. The fronts are of heavy plate glass 22 mm. thick, set in red-lead cement in iron frames. The four small aquaria at the ends of the room are 90 cm. long by 62 cm. wide by 54 cm. deep. They are in iron frames, with wooden base, and glazed on four sides. Through the center of the room is a bank of six aquaria, 80 by 62 by 54 cm., with overhead gas lights. The pump room (2.3 by 5 m.) communicates directly with the passageways (3 by 12.4 m.) above the tanks. The outer wall of the attendance gallery is glazed throughout with vertically placed semiopaque ribbed glass for lighting the aquaria.

The receiving room (5.4 by 8.64 m.) is provided with Dannevig hatchery boxes, wooden fish-tank 1 by 3 m., and wooden sorting-table tank 0.7 by 4.4 m.

The second floor contains all of the laboratories. A chemical laboratory (4.2 by 7.4 m.) and a director's office and laboratory (4.8 by 7.4 m.), containing two cubicals (2.5 by 3 m.) and a small reference library, are in the eastern end of the building and the main laboratory (8 by 12.8 m.) in the western end. This laboratory contains four cubicals (2.5 by 3 m.), a central aquarium rack (1.5 by 8 m.) with overhead salt and fresh water supply, slate shelf for glass and wooden aquaria (Pl. LI, *B*), and lead-lined base with sloping bottom and central drain channel. The fresh-water supply has a special filter and constant-pressure reservoir. Upon the south side of the room there is a continuous work table with desks for four persons

A. STATION BUILDING WITH SEAL POND IN FOREGROUND.

B. INTERIOR OF GENERAL LABORATORY, SHOWING AQUARIUM STAND.

BIOLOGICAL STATION AT BERGEN.

facing the windows. The cubicals are provided with work table (0.75 by 3.3), shelving, and desk 0.85 by 1.8. The third floor contains the keeper's quarters.

The building is heated and lighted by gas and has fresh and salt water supply in the laboratory. There is the usual provision of chemicals and glassware, paraffin baths and microtomes for biological work, and a small amount of physiological apparatus.

The library of the Bergen Museum (32,000 volumes), not far from the station, is available for use at the station. At the museum will also be found a very extensive collection of the Norwegian fauna and flora. The collection is especially rich in cetaceans, fishes, and marine invertebrates generally, and contains many type specimens of the latter.

The museum of the Norwegian Fisheries and Marine Investigations Bureau is also rich in collections of the marine fauna, especially of the food fishes and the pelagic life of Norwegian seas.

The Bergen station, in conjunction with the fisheries bureau, is very well equipped for oceanographic and hydrographic investigation. It has the instruments of this line of research of the International Commission for Investigation of the Sea, young-fish trawls, plankton nets, Nansen closing nets, Nansen current meters and water bottles, Richter thermometers for deep-sea work, apparatus for chlorine determination, and Fox gas-analyses apparatus for determination of oxygen, nitrogen, and carbon dioxide dissolved in sea water.

The station has one row boat. Small steamers or other boats can readily be hired at Bergen for collecting trips in the fiords or for more extensive biological and hydrographical explorations.

The water supply for the station and aquaria is drawn from Puddifiord, in a cast-iron pipe carried 200 m. to a depth of 9 m. below mean tide level, by an iron pump driven by a turbine motor of 2 horsepower, connected with the city water supply. It is in constant operation and the water is carried directly to the circulation system of galvanized iron and lead pipes with outlets of glass tubing with glass stopcocks. In places the piping is made of galvanized sheet iron. A small tank on the third floor provides a reserve supply of water. The marine algæ thrive in the Bergen aquaria, possibly as a result of the absence of copper in the metal of the circulation system.

The water supply is drawn from the Puddifiord, which receives some sewage and industrial wastes, but the contamination is not sufficient to interfere with aquaria in which anemones, holothurians, tunicates, and fishes thrive.

The salinity of the water ranges from 28 to 33 per mille, averaging 31 (sp. gr. 1.023 to 1.027), and the temperatures range from a maximum of 18° C. in summer to a minimum of 4° in winter.

The Bergen station is primarily and solely a research institution. It makes no provision for elementary instruction of teachers or for fishermens' classes. The aquarium is extensively utilized by the schools of Bergen, special reduced rates of admission being made for classes accompanied by teachers. It has no official connection with fisheries, either scientific or practical. It is resorted to by investigators for purposes of research. Practically all of the biologists of Norway have carried on investigations here and the station is widely known and utilized by continental and, occasionally, by British investigators. The combination of an outing in Norwegian fiords and mountains with the opportunity to utilize the unique facilities which the station offers for biological and hydrographical investigations, yearly brings many university professors and instructors and advanced students to the Bergen station.

Although primarily and solely an institution of research, the station through its connection with the museum has become an active agency indirectly in instruction in advanced marine biology and oceanography. Since 1903 summer courses have been given at the Bergen Museum, and under its patronage. The instruction is given largely by members of the staff of the station, the museum, and the Norwegian fisheries bureau, and use is made of the equipment of the station and the results of its work, while some of the laboratory exercises are also held at the station. These courses are attended by fifteen to thirty investigators each year. The following was the programme of the courses for 1908:

"Course of instruction on ocean research of the Bergen Museum from the 10th of August to the 15th of October, 1908.

"The courses will consist partly of lectures and practical instruction and demonstration in laboratory work, partly in excursions for studies of the invertebrata fauna. The course will be conducted according to the following plan:

"I. Dr. A. Appellöf: (1) Systematic examination of representative forms of the invertebrate animals in the fiords, the North Sea, and the Norwegian Sea. Demonstration of the most important species and guidance to their determination. (2) A review of the distribution of the bottom fauna in the same districts, and its dependence upon the configuration of the bottom and upon hydrographical conditions. (3) Excursions in the adjacent fiords, for the purpose of studying the invertebrate fauna. Opportunities will also be given for morphological study (dissections, etc.) of various types of invertebrates.

"II. Dr. D. Damas: (1) Animal plankton: Systematic examination; special attention paid to fish eggs and young fish. (2) Ordinary plankton biology.

"III. B. Helland-Hansen: Lectures combined with laboratory practice, on the main features of the oceanography of the North European waters (methods and results).

"IV. E. Jörgensen: The phyto-plankton of the North-Atlantic (Diatoms and Peridineæ), with demonstrations of all the important plankton species. Also other groups of plankton-protists will be dealt with, if desired.

"V. Docent C. F. Kolderup: (1) The bottom deposits of the ocean. (2) Glacial and post-glacial deposits in Norway (especially with regard to the mollusc-fauna).

"The lectures are arranged so that it is possible for all the students, if they so wish, to attend them all. Besides, special courses will be held for specialists in hydrography and plankton, combined with scientific researches in laboratory and on excursions. The lectures will be given in German, but outside the lectures the teachers also make use of English and French. Those who take part in the biological courses must bring their own microscopes, dissecting stands, and instruments.

"Each student is charged a fee of 150 kronen, Norwegian money (about £8). All wishing to attend the courses should apply to the oceanographical institute of the Bergen Museum before the 1st of July. Information as to lodging, etc., will be given if desired."

Although the station is quite independent, as an institution, of the fisheries bureau, it has been nevertheless closely associated with its work, since the hydrographical and plankton work of the bureau has been carried on in its laboratory and members of its staff are also upon that of the fisheries bureau. Some of the recent investigations of the director of the station have been concerned with the physical conditions affecting oyster culture in Norwegian waters.

Qualified investigators are admitted to the privileges of the station upon application to the director. A fee of 40 kronen per month is charged for an investigator's table. This fee covers the cost of all ordinary supplies, but expensive chemicals, collections involving much time, or of large extent are to be paid for at cost. Each person is expected to provide his own microscope and accessories. The station undertakes to provide materials for investigation prepared to order at cost of preparation. Herr Glimme's success in this work is favorably known to many European investigators. No list of biological supplies is issued. Collections may be made at the station for museum or class use under the supervision of the director.

The Bergen station occupies a wholly unique position among marine laboratories in the character of the environment. Situated upon a sheltered fiord, 18 miles from the open sea, it offers an extreme range of physical conditions for exploration by the hydrographer and biologist. Depths of 100 fathoms are found within a mile of the station,

400 fathoms in Osterfiord and 700 fathoms in Sognefiord. The surface strata of the fiord waters become more and more mingled with fresh water toward the head of the fiord. Submarine barriers separate the fiords into many basins, whose deeper waters show varying degrees of isolation from each other and from the tidal waters of Atlantic origin, even to the extreme of stagnation. Extremes of temperature in midsummer range from 3° C. in lower levels to 35° C. in small inclosed basins. The narrow fiords exhibit splendid examples of stratification of water, afford magnificent opportunities for the study of currents, temperatures, and salinities in relation to the physical problems of oceanography and to the plankton, abyssal, and litoral faunas, and to the practical problems of the fisheries.

The sheltered fiords afford ideal conditions for the prosecution of hydrographical and œcological work with a maximum of diversification and opportunity and a minimum of marine hazard, cost and expenditure of time.

The life found in the fiords is as varied as the physical conditions. The tidal amplitude averages 88 c m., has a mean maximum at spring of 119 cm. and at neap of 56 cm. The maximum spring tide is 161 cm. There are in places a *Fucus* and a *Laminaria* zone, but the shores of the fiords are generally steep and the area exposed at low tide limited and tide pools relatively rare. Limited areas of sand, gravel, and mud flats are available in the Lungegaardsvand adjacent to the station. The great variety of temperatures and salinity and the considerable range in depth of the fiords afford a great diversity of bottom and littoral fauna. The rocks at tide levels are covered with a dense growth of small *Mytilus* and of *Fucus*, and at deeper levels mollusks, crustaceans, echinoderms, especially holothurians, abound. Among the rare animals known to occur in the Bergen fauna are *Amphioxus*, *Myxine*, and *Rhabdopleura*.

The plankton is abundant and varied, Atlantic organisms being abundant even to the heads of most of the fiords in certain levels.

Bergen is one of the great fish markets of the world, and a visit to the quay on Saturday morning is quite interesting to the biologist. The common food fish are kept alive in tanks of sea water. Many fishing boats hail from Bergen and adjacent fiords and add considerably to the range of material available for investigation at the Bergen station.

A preliminary list of the fauna was published by Doctor Brunchorst (1891), and later the investigations of Nordgaard (1897, 1898, 1899) contain a discussion of the fauna and the physical conditions about Bergen. The more recent investigations of the Norwegian fisheries bureau, "Norwegian Fisheries and Marine Investigations" (1900), under the editorship of Doctor Hjort, and also those appearing in the publications of the International Commission for the Investigation

of the Sea, have added greatly to the detailed knowledge of the life and physical conditions in Norwegian waters, especially of the fishes and the plankton. A series of detailed systematic monographs of the "Meeresfauna von Bergen" under the editorship of Doctor Appellöf is in process of publication by the Bergen Museum. Three numbers of this series have thus far appeared, dealing with the Bryozoa, Decapoda, Hydroida, holosome ascidians, and calcareous sponges. They form a very useful manual for the biologist wishing information regarding the local fauna represented in these groups. In connection with the summer courses in oceanography the museum has issued a series of Bestimmungstabellen of the local fauna for class use, which afford a fair conspectus of its more abundantly represented species.

The Bergen station publishes no series of its own, the work done at the station appearing in the publications of the Bergen Museum, in its various monographs, its Aarbog and Aarsberetning, and elsewhere in Norwegian and continental biological journals.

The present lines of investigation by the staff of the station include an examination of the oyster grounds and a detailed scientific survey of several adjacent fiords, from the geological and hydrographical standpoints, a determination of environmental factors, such as temperatures, currents, circulation, salinities, dissolved gases, bottom deposits, and plankton, with reference ultimately to a complete biological survey of a typical fiord.

Bergen is quite a tourist center, and American investigators will find Norwegian pensions conveniently located with reference to the station at moderate charges.

The Bergen station offers peculiar attractions not only to the student of biological problems which deal with the classification, morphology, or development of northern forms, but especially to those interested in the recent development of œcological investigations which seek to correlate the life of the sea with the factors of the marine environment. In hydrographical lines and in its facilities for the attack upon many of the profounder problems of oceanography and in the relation of these problems to the practical work of commercial fisheries, its position is unique among the stations of Europe. It is to be hoped that this station, in conjunction with the great Bergen Museum, may ultimately become a great oceanographical university befitting the hardy race of seamen from which it has sprung.

Literature: Brunchorst (1891, 1893, 1900), Dean (1894), Sand (1897), Nordgaard (1897, 1898, 1899).

TRONDHJEM BIOLOGICAL STATION, HAEGADALEN, NEAR TRONDHJEM.

Director, Dr. O. Nordgaard, Trondhjem Museum, Trondhjem, Norway.

Coincidently with the agitation at Bergen and Christiania for the establishment of biological stations in these localities there arose also in the Trondhjem-Romsdal district a demand for a similar institution in the more northern waters. At a fisheries convention at Christiansund in February, 1891, a resolution was passed urging the establishment of a station. From the first there was an insistent demand for the practical application of the institution to the problems of the fisheries, which after years of discussion finally resulted, in face of strong opposition, in the combination of plaice and trout hatcheries with the station. An executive committee of business and professional men appointed in September, 1891, after many conferences, finally purchased the estate of Haegadalen, on the west coast of the harbor, 3 kilometers from the market place in the city. This location afforded a fresh-water stream for the trout hatchery and a site for the station sufficiently remote from contaminating sewage and industrial plants. The slow accumulation of funds and above all the differences of opinion as to the purposes and functions of the station, especially in regard to the public aquarium and the extent of the hatchery, delayed its realization for nearly ten years. Building was finally commenced in the summer of 1899 and the completed buildings were formally opened July 3, 1900. The total cost of the plant, including the property purchased for the site, was about 80,000 kronen. Of this, 71,150 kronen came from the annual surpluses of the Braendevinssamlag of the communes of Trondhjem and adjacent districts, and the remainder from public-spirited citizens, many of whom had also contributed generously in time and service to the enterprise.

The heavy expenditures for site, for the dams in fresh-water stream, and for blasting hatching basins in the solid granite consumed a relatively large amount of the funds, with the result that the actual station building and equipment are not so extensive as those at Bergen and Dröbak, where the available funds were not so great.

The first director, Cand. phil. Knut Dahl, was chosen by a committee composed of representatives of the Academy of Sciences, the Fisheries Society, municipal authorities, and the business interests. He was followed in 1903 by Dr. Gustav Swenander, who was succeeded in 1906 by the present director, Dr. O. Nordgaard, formerly director of the Bergen station. The director has control of all station matters and reports annually on the progress and needs of the institution to the station committee, consisting of representatives of the provincial government, the museum, the Fisheries Society, and two members elected by the city authorities. This committee nominates the director, who is approved by the Kultus Ministerium.

The staff of the Trondhjem station consists of the director, engineer, and keeper. The director is also curator of the zoological museum of the Kgl. Norske Videnskabers Selskab in Trondhjem. There is no resident naturalist.

The income of the station is 6,300 kronen per annum, derived as follows:

	Kronen.
Kultus ministerium	3,300
Fisheries bureau	1,000
Braendevinssamlag	1,000
Trondhjem Museum for fiord investigation	1,000

The expenditures are 800 kronen per annum for salary and 5,500 kronen for labor and upkeep. The aquarium is open to the public and a nominal fee of 20 and 10 ore is charged for admission, but only a small sum is realized from this source.

The Trondhjem station is not affiliated with any educational institution and gives no instruction to teachers, students, or fishermen. Its laboratories and aquaria are used solely in research and in the practical work of the fisheries, principally in the hatching of plaice and trout.

Properly qualified investigators are admitted to the privileges of the station, in so far as the limited room will permit, on application to the director. Investigators should as far as possible bring their research equipment with them, especially a microscope, as the station is not able to offer, as yet, fully equipped research tables. No fees have been charged in the past. The station is open throughout the summer months. Biological material is supplied to universities and investigators by arrangement in advance with the director.

The lines of investigation at present followed at the station consist of faunal and œcological studies of the life in the fiord, especially of the bryozoans and mollusks with special reference to the conditions under which they are found. In conjunction with this the fossil deposits in the margins of the fiord have been investigated with reference to change in sea levels. The station has no special publication of its own, the investigations carried on here appearing in various journals, principally in the "Skrifter," of the academy at Trondhjem.

The grounds of the Trondhjem station consist of a property of 136,419 sq. m. on the precipitous ridge west of the harbor, with a narrow shelf at the base where the buildings find a foothold. The holding contains a small stream on which are five dams and small reservoirs which afford the water supply for the station and trout hatchery. The station is reached by a public road from the city running along the railway. A motor boat calling at the island of Munkholmen also makes occasional trips to the station. The buildings of the Trondhjem station are at the water's edge at the base of a

rocky ridge about 2 m. above the level of mean high tide. The main building is a wooden structure of three stories. Its long axis runs approximately north and south, with the front to the east. The building consists of a main part (23.4 by 6 m.) with an extension to the east (8 by 9.1 m.). The northern part of the main building (6 by 11 m.) contains the plaice hatchery with loft for nets and tackle. In this room are twelve Dannevig hatching boxes with an agitator run by a water wheel which is interposed between the reservoir and the hatching circulation. The remainder of the ground floor contains the vestibule (4 by 6 m.) with central fresh-water aquarium (1 by 2 and 0.85 m. in height), a sorting room (4 by 3.5 m.), and the fresh-water fish hatchery (4 by 6 m.) containing two cement aquaria (2.4 long by 0.54 deep by 0.65 m. width) with filtering apparatus and hatching boxes for hatching salmon trout. The floor throughout the lower story is of cement. The eastern extension of the building and the cement vestibule are divided into two instead of three stories and contain on the ground floor the aquarium room with central public hall (4 by 6 m.) with illumination only through the peripherally arranged aquaria. These are ten in number and of various dimensions, the largest being 2 by 2.7 m., and the smallest 1.22 by 0.9 m. The depth of the aquaria is 1.1 m.

The aquaria lie in a peripheral corridor 2.5 m. wide, lighted abundantly by vertical windows draped to moderate the light as needed.

The second floor of the main building contains the director's private laboratory (4 by 5.2 m.) and a small room (3.5 by 4.1 m.) used as reagent room and keeper's laboratory. Over the aquarium room is the main laboratory (8 by 9 m.) with wall table on three sides with accommodations for seven to ten workers and a central aquarium rack (7.4 by 3) with overhead salt and fresh water supply and lead-covered table base.

The other rooms upon the third floor are a central reading room (4.1 by 6.5 m.), a storeroom (4.1 by 5.6 m.), and a room used for living quarters (2.3 by 4.22).

In addition to the laboratory hatchery building proper there are several other buildings, a machine shop, and pump house (5 by 7.7 m.), and a plaice spawning house (7.75 by 14 m.) containing a basin excavated in the rock (5 by 10 m. and 3 m. deep). A larger basin has been blasted in the granite for a plaice pool, but leakage has thus far prevented its use. There are two houses for the families of the keeper and engineer.

The water supply for the station is pumped through a sea pipe of 3-inch wire-bound rubber suction hose 150 m. long, with intake at a depth of 50 m. The rubber surface has the advantage of not being clogged by the attachment of *Mytilus*. A 3-horsepower petrol motor and a California pump with a capacity of 17,000 liters per hour are

used for pumping the water to the masonry reservoir (6.2 by 6.2 by 1.5 m.) with a capacity of 26,000 liters, at an elevation of 7 m. above mean high tide.

The pipe line from the pump to the reservoir is of galvanized iron. The distributing system for the salt water is entirely of lead piping with cocks of a composition of lead and tin (one part lead to two of tin). The cocks and valves are of the same caliber as the pipe, to permit cleaning out of the *Mytilus* which accumulates therein after the breeding season. The water is delivered to the aquaria through glass aerating air pumps and to the aquaria racks in the main laboratory through small glass cocks. The surface waters of Trondhjem fiord are usually below the normal salinity of sea water, but the supply for the station is drawn from a depth which insures approximately normal salinity.

The station is supplied throughout with both fresh and salt water, but has no connections with gas or electric plants, and only the smaller rooms have heating facilities. The equipment in glassware and chemicals is limited to the supplies necessary for the simpler lines of zoological work. The marine equipment is extensive and excellent. The museum and station have a motor boat, the *Bios*, 30 feet in length and 6 feet beam, with a 4-horsepower petrol motor. The boat is rigged with a winch connected with the motor and carrying 800 meters of dredging cable. A sail boat and several rowboats also belong to the station. The equipment of nets, seines, trawls, fish traps and dredges is ample. The station is not equipped for hydrographic work beyond some deep-sea thermometers and a water bottle of the Pettersson-Nansen type. No library or museum is maintained at the station, but the extensive library (70,000 volumes) of the Kgl. Videnskabers Selskab and rich collections of northern invertebrates and vertebrates in the zoological museum are accessible to the investigator desiring to work at the station.

The Trondhjem station enjoys the unique distinction of being the most northern of all biological stations open throughout the year. Located (63° 30′ N.) within 3 degrees of the Arctic Circle and in the latitude of Iceland it nevertheless enjoys a relatively mild climate even in winter. "In summer the climate is like that of the south of England and its winter climate like that of Dresden." The fiord never freezes. The climatic conditions are thus exceedingly favorable for so high a latitude.

The fauna of this fiord has been investigated, among others, by Storm (1901) and Norman (1895), whose papers give the most comprehensive summary of the biological material available in these waters. The extensive monograph by Nordgaard and Jörgenson (1905) dealing with the bottom life and the plankton of the Norwegian fiords is also serviceable as a guide to the contents of these biological areas in the Trondhjem fiord.

Between the station and the city is an extensive area of relatively shallow water less than 60 m. in depth, but the greater part of the adjacent fiord is of considerable depth, exceeding 200 m., while at 17 km. from the station a maximum depth of 550 m. is found. Trondhjem fiord has long been noted for the abundance and richness of its fauna and flora. It is, indeed, reputed to be the richest fiord on the Norwegian coast. The great extent of the shore line, the considerable range in depths, and the large quantity of plankton produced in the coastal waters in this latitude all combine to add to the abundance and diversity of the life in the waters of this sheltered fiord. As elsewhere in the fiords, the shores are steep, with narrow belts of *Mytilus* and *Fucus* adhering to the rocky walls and *Laminaria* rising from the deeper submerged rocks. The bottom is generally of fine sand and mud. In the straits of the fiord, where large quantities of plankton-rich water are carried past daily by the tidal currents, an exceedingly rich fauna is found upon the sides and bottom. The tidal amplitude at spring is 1 meter. On these steep slopes or the adjacent bottom are found great masses of sponges, gorgonians (*Paragorgia, Primnoa, Muricæa*), corals (*Lophohelia, Amphelia*), basket stars (*Astrophyton*), crinoids (*Antedon, Rhizocrinus*), brachiopods (*Terebratula*), together with many crustaceans, mollusks, hydroids, and actinians. Practically all of the hydroids and echinoderms known in Norwegian waters are found in Trondhjem fiord. Doctor Norman (1893–1895) reports 189 species of Amphipods from this territory, while but 143 were reported at that time from the Mediterranean Sea. Practically all of the fauna of southern Norway reaches the Trondhjem fiord, and to this fauna are added many boreal forms and not a few representatives from the arctic regions. The high latitude, quiet waters of the fiord, and the rich fauna make the Trondhjem station one of exceptional value to the investigator of the life in northern seas.

Literature: Anon (1901), Norman (1893–1895), Storm (1901.)

BIOLOGICAL STATION OF THE UNIVERSITY OF CHRISTIANIA, DRÖBAK, NORWAY.

Director, Prof. K. E. Schreiner, M. D. Address: Anatomiske Institut, Universitet, Christiania, Norway. July and August, Dröbak, Norway. Telegraph address: Biologen, Dröbak.

The biological station of the University of Christiania is beautifully located on a rocky promontory projecting into Christiania fiord at Dröbak, 28 miles south of Norway's capital. It lies upon the eastern shore at a point where the fiord is relatively narrow and commands a fine view in all directions.

The station owes its origin to the persistent efforts of a group of scientific men at the university. In 1890 Prof. Fridthjof Nansen

was called to the university from the Bergen Museum, and in October of that year Prof. G. A. Guldberg, with Profs. R. Collett, F. Nansen, G. O. Sars, S. Torup, and N. Wille, constituted themselves a committee to develop a biological station near Christiania, and proceeded by a series of public lectures on biological subjects to arouse popular interest in the project. Subscription lists were opened and a canvass was made for funds. Plans were made for a building and a site accepted at Dröbak in 1892. Construction was begun in 1894, and the building was formally opened for scientific work June 23, 1894. The cost of the building was 23,000 kronen, of which 18,000 were given by the Christiania "Braendevinssamlag" and the remainder by citizens of Dröbak and Christiania. A subsequent grant from the state of several thousand kronen was made for equipping the station, and in recent years 5,000 kronen have been expended in building a masonry shelter harbor for the boats of the station.

The station at the time of its construction was taken over by the Kultus Ministerium of the state and supported by an annual grant of 2,000 kronen, being administered by a committee of three from the faculty of the university, namely, Profs. Guldberg, Torup, and Wille. This arrangement continued until 1897, when Dr. Johan Hjort was appointed director. He was succeeded in 1900 by Prof. N. Wille, who held the position till 1902, when the station passed into the direct control of the University of Christiania. Its administration is at present primarily in the hands of a committee of three of the faculty, Profs. Nansen, Sars, and Torup. The director is nominated by this committee and appointed by the university. The present director, Prof. K. E. Schreiner, was appointed January 1, 1902. The entire management of the station is in the director's hands. The budget for the station is approved by the university committee, and an annual allotment of 2,500 kronen is appropriated for its upkeep, for repairs, laboratory supplies, publications, and labor. The salary of the director, 800 kronen, is paid in addition by the university. The station has no resident naturalist and no permanent employees.

The station stands in ample grounds (3,000 sq. m.) and is a three-story building 3.5 m. above water level, 8 by 15 m., with its main axis east and west. Its first floor is of masonry and contains the main entrance and a workshop and tackle room (5 by 8 m.) and a receiving and sorting room (5 by 8 m.), formerly the public aquarium room. The second and third floors are of wood and contain, respectively, the main laboratories and the library and students' quarters.

The second floor contains a centrally located spiral stairway, a main laboratory (5 by 8 m.) to the east with places for six students, and a central aquarium rack for small aquaria; a small laboratory to the north (3.5 by 4 m.) with places for two investigators and adjacent dark room for photographic work, a physiological laboratory (3.5 by

5 m.) and a director's office and laboratory (3.5 by 5 m.) to the west, and a drawing and reading room (3.5 by 4 m.) to the south. The third floor has a library (5 by 8 m.), a room (3.5 by 4 m.) with dark room for biological investigations with light, and three rooms for student quarters. The station is heated with coal stoves.

The salt-water supply is stored in a small steel tank (capacity, 4.3 cu. m.) in the tower and is carried by galvanized piping with brass cocks to the work tables and aquarium racks. The public aquaria in the basement were removed because of the expense of maintenance and the interference with the work of the station caused by the admission of visitors. A separate building for aquaria is planned for future construction. The water is drawn from a depth of 10 fathoms below the surface, where a nearly constant salinity (30 per mille) is obtainable. The sea pipe is of 2-inch galvanized iron.

The water is at present pumped with a brass hand pump, a German petrol motor having been discarded as inefficient.

The Dröbak station is equipped with the usual reagents for morphological work, has also paraffin oven and microtome and a small equipment for work in physiological chemistry. Its library consists of about 1,000 volumes and pamphlets mostly relating to bibliography, to the local fauna, or to the work of Scandinavian biologists. The rapid communication with Christiania places the great resources of the library of the university and the Christiania Academy of Sciences at the disposal of the investigator at Dröbak, so that the greater part of scientific literature is within easy reach of the station.

The field equipment of the station consists of a sailboat and several rowboats, and an ample supply of dredges, tow nets, an otter trawl, a young fish net, long lines for fishing, fish and lobster traps, etc. The station possesses a sounding machine and deep-sea thermometers for oceanographic work.

The station is regularly open during the summer months.

High-school teachers are admitted to the classes when there is opportunity, and qualified foreign investigators are welcome to the use of such facilities at the station as may at the time be available on application to the director. The station will be opened at other seasons by special arrangement. No fees are charged. No biological supplies are regularly furnished or sold by the station and no museum of the local fauna is maintained. The station has no fish hatchery and is not in any way directly related to the fisheries industries.

The station is used primarily for summer instruction of university students and for the investigations of the biological staff of the university. Its room is quite limited, only eight tables being available. Summer instruction in marine biology is given by the director from July 1 to August 31 to university students. The

station is also used for excursions of university classes from Christiania and at times during university vacations, but is usually closed at other seasons.

Since 1897 the investigations carried on at the Dröbak station and published in various Norwegian and continental journals have been assembled in a series of reprints entitled "Meddelelser fra den biologiske Stattion ved Dröbak," No. 14 appearing in 1908.

The Dröbak station is admirably located for biological work. The Danish naturalist, O. F. Müller, was one of the first to discover its rich fauna. The great work of Michael Sars, "Fauna littoralis norvegiae," will give the visiting naturalist some idea of the available fauna, and the later exhaustive treatise on "The Crustacea of Norway," by G. O. Sars, gives a very complete catalogue of the fauna in this group. A complete biological survey of Sandspollen, a small arm of the fiord near the laboratory, was made by Kiaer (1904) and contains a list of the fauna accessible in that territory.

A series of reports upon the Chlorophyceæ of Dröbak have been published by Professor Wille (1901), and Professor Gran (1897) has given an account of seaweed flora of Christiania fiord.

The Dröbak station lies in the inner third of Christiania fiord about 60 miles from its mouth. The fiord is only 1 to 1.5 kilometers in width near the station, a configuration which gives greater rapidity to the tidal currents and conduces to an abundant littoral and bottom fauna. The shores of the fiord are steep and shelve abruptly to deep water. The tidal amplitude at spring is only 50 cm. and there are few tide pools. *Fucus* and *Laminaria* zones are present, but are generally narrow. The bottom of the fiord is very irregular in configuration. Depths of over 200 meters are to be found at a distance of 2 kilometers from the station, and this deeper water extends southward for a considerable distance to the submarine barrier at the mouth of the fiord. Rock, gravel, sand and mud bottoms are all accessible near the station, and several rocky banks at the depths of 5 to 10 meters afford rich and easily worked dredging grounds. At the head of several arms of the fiord in Sandspollen are small areas of sand and mud flats rich in worms and lamellibranch mollusks.

The *Mytilus* zone is less densely inhabited than at Bergen. The dredge brings up an abundant bottom fauna, of echinoderms, *Asterias*, *Spatangus*, *Echinus*, *Strongylocentrotus*, holothurians, and *Antedon*, very many hydroids, bryozoa, actinians, sponges, and mollusks. *Spinax* and *Chimæra* are taken on long lines in the fiord. The surface plankton is abundant and the deeper plankton rich in organisms characteristic of deep water. *Sagitta*, *Krohnia*, *Tomopteris*, *Diphyes*, *Aurelia*, *Cyanea*, many hydromedusæ and ctenophores, *Euchæta*, and other Copepoda are often abundant. The diatom

flora is a rich one and has been thoroughly investigated by Professor Gran.

Dröbak is a fishing village of some importance, and the equipment of the local fishermen and their knowledge of the fiord add materially to the biological resources of the station.

The salinity of the surface water is subject to considerable variation, ranging from 20 to 30 per mille, but the deeper waters are fairly constant. The temperature of surface waters ranges from about 15° C. in June, 17–20° in July, and 18 to 15° in August to 4° in winter. The water at Dröbak is relatively free from bacterial contamination. Its considerable distance from Christiania, the absence of a sewage system in that city, and the absence of industrial development in its vicinity insure to this station a high degree of purity in the sea water of the fiord in its vicinity.

Dröbak is readily reached from Christiania by numerous steamers, which ply at all hours between the two ports. It is a popular watering place much resorted to during the summer months. Good accommodations at very moderate charges can usually be secured in the village near the station.

Literature: Guldberg (1894), Dean (1894), Sand (1897).

FLÖDEVIG HATCHERY.

Director, Capt. G. M. Dannevig, Flödevigens Udklaekningsanstalt, Flödevig pr. Arendal, Norway.

In 1882 the popular demand for active measures for the preservation of the fisheries led the local fisheries society at Arendal to undertake the establishment of a fish cultural institution on the southern coast of Norway. Accordingly appeals were made to the national fisheries society, and their aid, together with that of the local savings bank, the Braendevinssamlag, and many private donors, made possible the erection of a substantial plant at Flödevig under the direction of Capt. G. M. Dannevig. The aid of the State was also secured for the upkeep of the work, but private funds to the extent of over 20 per cent (50,035 kronen) of total expenditure (222,338 kronen) has been given during the past twenty-five years. The total output of the plant has been 3,351,000,000 young fish, principally cod. Captain Dannevig has remained at the head of the institution throughout its existence.

This institution is notable for the work of its founder in developing and perfecting the widely used Dannevig hatching boxes and for his active propaganda in favor of the commercial value of sea-fish hatching. Experiments to prove the validity of this conclusion have been carried on by Captain Dannevig (1908; see also Hjort, 1908, 1908a), in Norwegian fiords with seemingly favorable results. The conclusions of the extensive and broadly based "International

work" (see Hjort, 1908) are, however, adverse to the value of sea-fish hatching.

The Dannevig hatching tanks are widely used throughout Europe and are especially valuable in my opinion as culture tanks for many marine invertebrates and might well constitute a part of the equipment of every biological station. Captain Dannevig has recently published (1910) a detailed account of this apparatus; and modifications designed to use the circulating water as power for the agitator, devised by Scott and Johnstone, of the Liverpool Fisheries Laboratory, have recently been described by Herdman (1908) and are figured elsewhere (figs. 22–28).

The plant at Flödevig consists of a two-story wooden building (30 by 40 feet), with first floor given over to the hatchery, containing a large number of Dannevig tanks operated by water power. There is also a central aquarium (3 by 4 by 2 feet) on cement base. The upper floor provides for an office and small laboratory and a large store room. The engine and pump are lodged in an adjacent machine house. The station also has two salt-water basins, a receiving basin (6 by 19 m. and 3 m. in depth), and a rearing basin (22 by 34 m. and 5 m. in greatest depth), with provisions for preventing extreme changes in salinity.

The Flödevig station issues annually a Beretning for Femaaret.

Literature: Sand (1897), Dannevig (1907, 1908).

FISHERIES BOARD OF NORWAY.

Norwegian Bureau for the International Investigation of the Sea.

Director, Dr. Johan Hjort, Fiskeridirektorens Kontor, Bergen, Norway. Telegraph address: Fiskeridirektor, Bergen.

Scientific assistants: Dr. Knut Dahl, food fishes, Salmonidæ; Dr. D. Damas, biological station, Bergen, pelagic eggs and fry; O. Sund, field assistant, steamer *Michael Sars;* Einar Koefoed, field assistant, steamer *Michael Sars.*

Director of physiological laboratory, Henrik Bull, Fiskeriforsögsstation, Bergen, Norway.

Captain of the *Michael Sars*, Thor Iverson.

The work of the Norwegian section of the International Commission for the Investigation of the Sea is directly in charge of the Norwegian fisheries bureau with headquarters at Bergen. Its biological and hydrographical work is carried on in connection with the Bergen biological station, the director of the latter, Mr. B. Helland-Hansen, having charge of the hydrographical work of the bureau.

The bureau maintains no biological station or laboratories beyond the workrooms in its Bergen offices. It has, however, an experimental laboratory or "Fiskeriforsögsstationen" in Bergen in which are conducted investigations on methods of preparation and preservation of fish and fisheries products.

The research ship of the Norwegian bureau, the *Michael Sars*, has proved to be one of the most satisfactory of the larger ships engaged in the hazardous work of carrying on continuous scientific investigations in the storm-swept waters of the North Sea. It represents the experience of a sea-going people engaged in the exploitation of the resources of the sea, and embodies an adaptation of their methods to the problems of oceanic research. Its construction and equipment are eminently practical and efficient, and might well serve as a model for the smaller types of vessels engaged in fisheries and deep-sea explorations.

The *Michael Sars* is a steel vessel of schooner rig, 39.2 m. long, 7.2 m. wide, with draft of 3.8 m. and a gross tonnage of 226.47. It has compound engines of 300 indicated horsepower and a speed of 10 to 11 knots per hour. A steam winch of 20 horsepower carries 4,000 m. of dredging cable in four sections, diameters of 19 and 12.5 mm., respectively. There are also smaller reeling engines for cod lines and hydrographic apparatus and plankton nets, and 4,000 m. of 3 mm. cable for this lighter work.

The *Sars* is equipped with a complete outfit of commercial trawls, otter trawls, seines, and nets, Petersen young-fish trawl, a young-fish trawl (Damas) of circular form of large size with otter boards for keeping it open when in service; Nansen closing nets, plankton nets, and a complete outfit of the international hydrographic instruments. There is a small, well-lighted laboratory aft, with accomodations for six workers and ample deck room fore and aft for the landing of catches and work with apparatus. The ship carries five officers and a crew of twelve. Her home port is Bergen. Persons wishing to observe work of the ship should apply in advance to the director.

The field of operations of the Norwegian bureau is the waters adjacent to Norway and its many fiords. The more northerly part of the North Sea is also assigned to this bureau in the international programme. The lines of investigation followed have been the distribution and migrations of the food fishes, the location of spawning regions and distribution of eggs and fry, especially of the fishes of the cod family and the herring. Exhaustive experiments have also been carried on to test the value of the artificial hatching of pelagic sea fish such as the cod, with the significant conclusion that all such feeble efforts on man's part in no appreciable way affect the colossally great fluctuations in the numbers of such fish in the sea. Correlation of the biological and hydrographical observations has been a prominent feature in the work of this bureau.

The results of the work have appeared in the "Aarsberetning vedkommende Norgen Fiskerier" and in the "Reports of the Norwegian Marine and Fisheries Investigations" (2 vols., 1900–1909).

Literature: Hjort (1901, 1908, 1908a).

CENTRAL LABORATORY OF THE INTERNATIONAL COMMISSION FOR THE INVESTIGATION OF THE SEA, CHRISTIANIA, NORWAY.

Director, Prof. Fridtjof Nansen, University of Christiania.
Assistant, Dr. V. W. Ekman.

This central institution was established in 1903 primarily as a physical laboratory to assist in developing and standardizing the instruments used in the work of the International Commission for the Investigation of the Sea, and incidentally to determine some of the physical constants of problems arising in marine investigations.

Among the instruments and apparatus, standardized and supplied through this laboratory, were the Richter [a] reversing deep-sea thermometers now sent out with certification of the Physikalisch-Technische Reichsanstalt of Charlottenburg, near Berlin; the Chun-Pettersson self-closing water bottle,[b] the Fox gas analysis apparatus [c] (see Fox, 1905) for the determination of gases dissolved in sea water, the Felton and Guillaume [d] sounding and dredging cables, and meter wheels [e] for registering the passage of cables. The laboratory was also instrumental in perfecting the Ekman self-closing water bottle [f] for use in series, and the Ekman full-speed water bottle [f] for collecting water samples for salinity and gas analysis (see Ekman, 1905), also the Ekman suspended current meter [e] (see Ekman, 1905a) for use with anchored ships, the Nansen [f] tripod current meter (see Nansen, 1906) for bottom currents, the Nansen bottom sampler [f] (see Ekman, 1905b), and the Nansen self-closing plankton nets [f] for vertical plankton hauls.

The Knudsen burettes for chlorine analysis [g] and standard sea waters for checking chlorine determinations were also furnished by the laboratory. The standard sea water is now furnished by the central hydrographical office, Dr. M. Knudsen, director, Jens Koefoedgade 2[1], Copenhagen.

The laboratory was discontinued in 1908.

Literature: "Rapport" and "Occasional papers" of the International Commission for the Investigation of the Sea, Copenhagen, 1903–1908.

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[a] Made by C. Richter, 30, Lehrterstr., Berlin, Germany.
[b] Made by L. M. Ericsson & Co., Stockholm, Sweden.
[c] Made by G. Müller, Ilmenau, Germany.
[d] Made at Mülheim, Germany.
[e] Made by instrument maker, C. A. Ljungman, Christiania, Norway.
[f] Made by instrument maker, L. Anderson, Christiania, Norway.
[g] Made by R. Goetze, Hartelstr. 4, Leipzig, Germany; also by Müller, Ilmenau.

SWEDISH MARINE ZOOLOGICAL STATION, KRISTINEBERG, SWEDEN.

Post-office, Fiskebäckskil, Zoologiska Havstation.
Telegraph address, Fiskebäckskil, Zoologiska Havstation.
Prefekten, Prof. Hjalmar Théel, Kgl. Svenska Vetenskapsacademien, Stockholm.
Föreståndaren, Dr. Arthur Hjalmar Oestergren, Fiskebäckskil.
Vagtmästaren, Henrik Hansen.
Draggmästaren, Albert Henrickson.
Hushållerskan, Fröken Julia Olsson.

One of the admirably located and well-equipped European marine laboratories is the Swedish marine zoological station at Kristineberg. It is unfortunately one of the least known to investigators, partly because of its seeming remoteness from usual routes of travel, and partly from the still lingering belief that the use of its facilities is limited to Swedish students and naturalists. On the contrary this earlier regulation was long since abolished, and the most cordial welcome at Kristineberg awaits the investigator or naturalist from other shores.

The station owes its location to the selection of Kristineberg as a summer resort by Swedish naturalists, beginning with the visits of Prof. Bengt Fries in 1835 and Prof. Sven Lovén in 1839. The place soon became a naturalists' summer colony, and the names of Anders, Retzius, Sundevald, Areschough, Johannes Müller, W. Lilljeborg, Lindstrom, Smitt, Thorell, Chr. Lovén, Torell, Bruzelius, Malmgren, and Sandahl are linked with the early history of this impromptu summer biological station.

The formal organization of the station was the result largely of the work of its first director, Prof. Sven Lovén, and the funds for its development came in the first instance in a bequest by a Swedish physician in Brazil, Dr. A. F. Regnell, of 55,000 kronen to the Swedish Academy of Sciences at Stockholm, for the express purpose of founding a biological station. In 1877 the trustees of the Royal and Hvitfeld scholarships at Gottenborg secured at Kristineberg the title to the grounds, buildings, and quays of Capt. E. Bengtsson, who had long served the visiting scientists as boatman and collector, and in August of that year the station was formally opened in these buildings with T. Tullberg, Chr. Aurivillius, and H. Théel among the young investigators eagerly engaged in its work. The station also received in 1879 the rich equipment in apparatus of the Gunhild expedition to the Skagerrack, which provided at the start a complete outfit for dredging and other marine investigations. In 1884 the first laboratory building was completed. In 1892 Prof. Hjalmar Théel succeeded Professor Lovén as director, and in 1903 the station was greatly enlarged and improved by the gifts of Consul G. E. Broms and his wife, Fru Anna Broms, amounting in all to 60,000 kronen. This sum provided for the erection of a new laboratory building

A. GENERAL VIEW.

B. THE SHELTER HARBOR WITH THE "SVEN LOVEN."

SWEDISH MARINE ZOOLOGICAL STATION AT KRISTINEBERG.

suitable for use in the winter months, a house for the keeper, an acetylene plant, new water tower, pump house, and circulation system, the new motor boat *Sven Lovén*, and extensive harbor improvements. In 1906 Dr. Hjalmar Oestergren became resident foreståndderen at the station and still continues in immediate charge of its work.

The station has played no small part in the development of the biological sciences in Sweden, and the roll of its investigators and students includes practically all of the names of Swedish biologists of the past half century. Much of the work done at the station is published by the Academy of Sciences at Stockholm and in the university publications at Lund and Upsala. The station has no publications of its own and has published no list of "contributions" from its laboratories.

The administration of the station is singularly simple and free from entangling affiliations or restrictions. The station is a branch of the Royal Academy of Sciences at Stockholm. The curator of the invertebrate section of the Royal Museum is ex-officio prefekten and the affairs of the station and the determining its budget are nominally in the hands of a committee of three appointed by the academy, of which the prefekten is chairman. This committee in 1908 consisted of Profs. T. Théel, G. Retzius, and T. Tullberg. The foreståndderen is nominated by this committee and confirmed by the academy. All details of management and control of the station are attended to by the foreståndderen, who resides throughout the year at Kristineberg. He makes an annual report to the academy which is published in the Årsbok of that institution. He also files each year a daybook or diary of station operations, dredging excursions, etc., but this is not published.

The station receives an annual grant of 4,000 kronen from the Kultus Ministerium of the State, but its administrative relationship to the educational bureau ceases with a report of expenditures. The universities of Sweden, as such, have no control over the station. Members of their biological faculties in their capacity as members of the academy have always, however, been concerned in the direction of the policy of the station. An obligatory part of the course of instruction of every zoological student in the universities of Sweden is the summer course in marine zoology given by the foreståndderen of the station at Kristineberg. Two summer sessions of six weeks' duration were held in 1908 with a total attendance of forty students. Since the demand for places exceeded the accommodations it is planned to hold three sessions of five to six weeks each in the future. The station is also utilized during the summer and at other times throughout the year by qualified investigators for the purposes of research and its excellent facilities are placed at their disposal without expense beyond the moderate charge (2.35 kronen per day in 1908)

for pension to those who take quarters at the station. The station is ordinarily well occupied during June–August. Applications should therefore be sent in advance, especially at this season, to the forestånderen by those who wish to carry on research at the station. The limitation of the use of the station to Swedish students only applies, at present, to the course of summer instruction. Qualified investigators of all nations receive a cordial welcome to the facilities for research at Kristineberg.

Teachers in the schools of Sweden are also eligible for admission to the summer courses and attend in some numbers, but no special instruction is given to them. The station has no classes for fishermen, and bears no administrative relation to the fisheries or to the biological and hydrographical work carried on in their investigation. It is thus purely a station for instruction and research in marine zoology.

The station furnishes material for collections and instruction to the universities and schools of Sweden free of charge except for preserving fluids and containers. It also generously provides material for research to other than Swedish investigators at the cost of collection and preparation.

The station at present makes no effort to maintain aquaria for exhibition purposes and the public are not admitted to the aquarium hall.

The income of the Kristineberg station in 1908 consisted of an annual grant of 6,000 kronen from the Swedish Academy and one of 4,000 kronen from the Kultus Ministerium. Of this, 5,400 kronen are paid in salaries to the director, keeper, dredge master, and matron, and 4,600 for labor, fuel, repairs, supplies, and upkeep. The station has been most fortunate in the number of donors who have given liberally to its equipment of machinery, water supply, instruments, books, and apparatus.

The Kristineberg station is located on the northwestern angle of Skafto Island, near the mouth of Gullmar Fiord, 1 kilometer west of the fishing village of Fiskebäckskil, and a little more than 2 kilometers from the port of Lysekil, on the northwestern shore of the fiord. Local steamers from Christiania and Göteborg call here. Connections by small fiord steamers can be made from Lysekil daily for Fiskebäckskil and also from Uddevalla, where railroad connections with Christiania, Göteborg, and Copenhagen are found.

The western coast of Sweden in this locality is studded with barren rocky islets, with rounded shoulders of granite and gneiss. Clustered in the narrow intervals of level ground and these granite knolls lie the red-tiled roofs of the little hamlet of Kristineberg. The grounds of the station are quite extensive, including immediately about the

station buildings about 10,000 sq. m. The station has also recently acquired from the trustees of the Royal and Hvitfeld scholarships fund in Göteborg the title to its grounds and also that of the adjacent islets and all unoccupied land in the vicinity to forestall any invasion of industrial plants or summer population which might lead to pollution of the waters or interference with its work. In this respect the Kristineberg station is most fortunate, for it now seems secure against the destructive results of the crowding of urban population and industrial establishments which has so marred the development of some European stations. Owing to the isolation of the Kristineberg station it forms a complete settlement by itself, with its own wharves and shelter harbor, fresh-water supply, and acetylene-gas plant, and also living quarters for its director and employees and for those who come to the station for study or research. It thus constitutes in reality a small village in itself. (Pl. LII, *A*.)

The early laboratory building, now known as the summer laboratory, was built in 1884. It stands at the water's edge, about 2 m. above mean tide. It is a wooden building of two stories and loft on masonry foundation, of rectangular form, 10 by 18 m., with its long axis north by west and south by east. The ground floor is entered by a corridor directly from the boat landing, or from the south by a larger main entrance, whence stairs lead to the upper floors. A short stair leads from the small lobby directly to the "skoljoummet," or washing room, a large room (6.5 by 11 m.), containing an elevated platform on which are five aquaria (*a*, *a*, *a*), while in the adjacent area are stored the tackle and gear in constant use. The floor beneath is constructed of strips of planking between which the rubbish and water fall to the underlying rocks and are washed into the sea. Immediately under the three windows runs a long sorting and dissecting table, with sink, and lifts to the rooms above. From the washing room one enters also a small laboratory (4.5 by 6 m.). The two small aquarium rooms formerly contained large cement aquaria. In the southeast corner is a sorting room (*c*) (4.5 by 5 m.), with wall table and sinks, and storage cellar beneath. This room is used for sorting and preserving the collections and contains a stock of reagents and glassware. The room (4.5 by 7.5 m.) originally planned as a laboratory is now used as a gear and store room for the marine equipment.

The second floor has a long central corridor, with reagent room (2 by 4.5 m.), glassware room (3 by 4.5 m.), director's laboratory (3.5 by 4 m.), and six rooms (3.4 by 4.5 m.) for individual workers. Each has an area of about 12 m. and a ceiling height of 3 m. Each room is fitted with ample shelving, sink, lift from the sorting room below, central aquarium rack, with copper tray and overhead slat

rack for glass aquaria, and salt and fresh water supply (see Pl. LIII, *B*), an angle desk with solid oak top, and treadle arrangement for a lens stand after the Sven Lovén model, and a set of drawers.

On the center of the south side is the large general workroom (4.5 by 6.5 m.), with central aquarium rack, desks for three students, chemical hood, and sink. In the attic is a large well-lighted loft used as storeroom for sails and the extensive marine equipment of the "Gunhild expedition."

In 1903 the new winter laboratory was begun and was opened for use in June, 1905. It is a substantial granite building (12.12 by 16.74 m.), with tile roof. It stands about 45 m. from the boat landing and about 4 m. above mean tide. It is a simple rectangular building, with its main axis running northeast by southwest and its main entrance to the southeast. Upon the ground floor one enters directly into the large aquarium hall (8 by 11.5 m.), which contains a central aquarium (see Pl. LIII, *A*) with a group of five small aquaria above it, while against the wall at the end of the room are five other large aquaria. Against the northwest wall at the center of the room is a paraffin hood, with flues, and adjacent cement tables (in all 6.5 by 3 m.), with gas for laboratory use and shelving for stock of common reagents. At the end of the room an open spiral stair leads to the floor above. Two large amply lighted private laboratories (each 4 by 7.25 m.) and a suite of two smaller ones (each 4 by 5 m.) and a dark room (2 by 4 m.) occupy the rest of the ground floor. The floor of the aquarium hall is of cement, but that of the laboratories of wood. The ceilings on both floors are 3.6 m. in height.

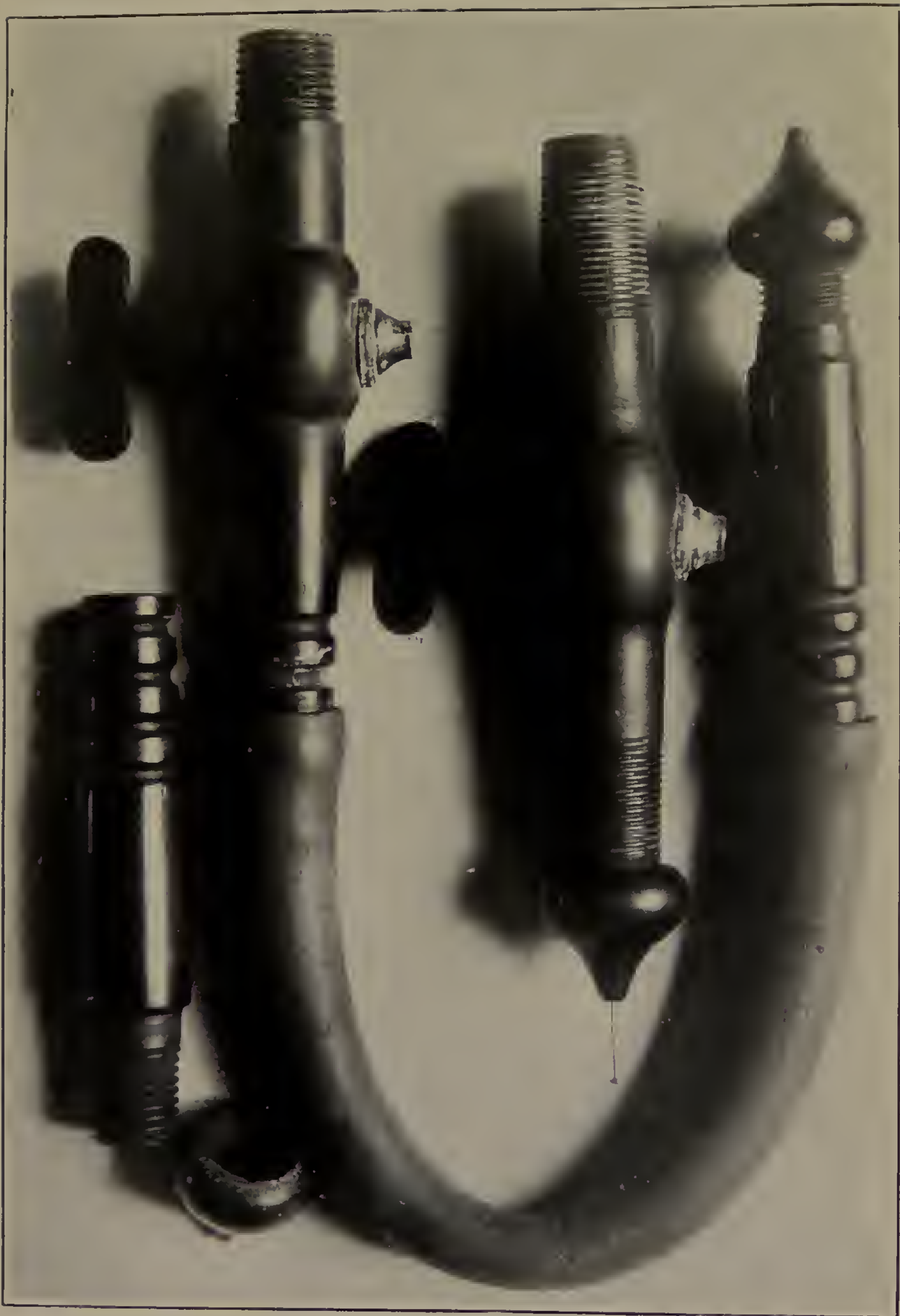
The stairs lead to a central hall (4 by 8 m.) on the second floor, with cases for glassware and apparatus, and a sink. From this hall open five rooms—a large library and assembly hall (7.2 by 7.2 m.), containing a large reading table, writing tables, bookcases, and fine busts of Prof. Sven Lovén and Charles Darwin; a large collection room (4.2 by 7.5 m.), with a carefully selected collection of the local fauna, fully labeled and systematically arranged. A table runs along the outer walls of this room. The remaining three rooms are similar in arrangement and dimensions to those beneath them and are similarly fitted as laboratories.

The laboratories in this building are all fitted alike with a substantial table shelf along the outer wall, 0.6 m. in width, a case of drawers beneath it, shelving for apparatus and books, an aquarium table with porcelain top (0.6 by 1 m.) with galvanized-iron rim and overflow to adjacent sink (0.4 by 0.5) and overhead water supply with a series of ebonite cocks. The glass used is unpolished plate with the under surface painted black with asphalt paint and the margins set in the metal rim in aquarium cement.

A. AQUARIUM ROOM, RESEARCH LABORATORY.

B. INVESTIGATOR'S ROOM, SUMMER LABORATORY.

INTERIORS, KRISTINEBERG STATION.



EBONITE COCKS WITH DETACHABLE TERMINAL, USED AT KRISTINEBERG.

The third floor is as yet a large unfinished loft used for storage of the surplus stock of collections and for the fresh-water and alcohol tanks.

The building is supplied throughout with acetylene gas, heated by coal stoves, and amply lighted with triple casement windows with lower lights, 48 by 135 cm. The walls are of painted wood or plaster, and the floors are deadened throughout the building with sawdust.

The water supply, circulating system, and aquaria at the Kristineberg station have been worked out with great care. The water is at present drawn from the sea through a 3-inch galvanized-iron pipe, carried 20 m. from shore to a depth of 3 m. The pump house stands at the water's edge and contains a 4.6 horsepower petrol motor and a Lundberg iron pump. A 3-inch galvanized-iron pipe 68 m. in length carries the water to the detached water tower. This is a square wooden building (8.6 by 8.6 m.) on solid masonry foundations 3.5 m. high. The tower contains four large wooden tanks (2.6 m. in diameter and 3.1 m. in height) with a total capacity of 70 cu. m. From the tanks the water is carried to the laboratories in galvanized-pipes with brass valves.

The distributing system in the earlier building is of glass tubing inclosed in an outer tube of brass with a packing composed of a mixture of beeswax and turpentine between the tubes. The angles and connections are of brass heavily tinned, but the brass has begun to corrode in recent years. The new winter laboratory has a distributing system of galvanized-iron pipes with brass valves. The terminal outlets in both laboratories are of a special pattern constructed for the laboratory. They are made of ebonite and combine so many excellent qualities that they deserve to be widely used wherever the overhead spray method of aeration is employed in aquaria. They are tubes of ebonite designed for attachment to rubber tubing (Pl. LIV) and have a small opening in the tip which is removable for cleaning out bits of débris or other obstructions which often clog the fine terminals of a circulatory system. They are made both with and without a cock.

Four of the large aquaria in the new building are floor tanks (see Pl. LIII, *A*) with solid cement walls lined with glazed tile of white, blue, green, and gray colors. The large central floor tank is 1.78 (1.38 inside) m. square and has a depth of 58 cm. and a capacity of 1,104 liters. Its walls are 20 cm. in thickness. The smaller wall tanks are each 1.03 by 1.35 and 0.6 m. in depth with a capacity of 500 liters, walls 16 cm. in thickness. All have bottom flush pipe and overhead water supply. The two remaining large aquaria are elevated on masonry foundations to a height of 0.85 m. They are lined, respectively, with black and white glazed title. Each has a plate-

glass front (0.8 by 1.2 m.) 2.5 cm. in thickness and set in iron frames in the cement walls. The glass has a backing of rubber tubing and is set in a cement of beeswax and Venice turpentine. The top is incased and has a window and gas jets for overhead illumination.

Five smaller aquaria with brass-bound oak frames and glass sides and bottom stand upon a framework over the large floor tank. (Pl. LIII, *A*.) Each is 66 cm. long, 44 wide, and 42 high, with overhead supply and central outlet bored through the glass plate in the bottom. The laboratories of both the new and old buildings are also provided with numerous small aquaria with brass frames 40 cm. long, 25 wide, and 23 high, with central outlet cut through the glass floor. There are also numerous glass dishes of assorted sizes with similar openings 24 mm. in diameter in the bottom for the cork containing the overflow pipe.

Doctor Oestergren has also recently constructed small aquaria from common glass plates cemented together with a mixture of ground glass (five parts) and calcium fluoride (one part), made up into a paste with silicate of sodium. The paste when hardened is covered with a thin coat of rubber cement or other waterproof varnish. These make strong light aquaria of great service for small animals or experimental work.

The older building contains in its "washing room" five aquaria, each 1 m. long, 0.5 m. wide, and 0.45 m. high, with brass-bound oak frames with glass sides and bottom, the longer faces and the bottom having three panes each. A central outlet passes through the glass bottom to elliptical Scandinavian wooden tubs, also used as aquaria. The large cement aquaria formerly used in the old building were removed to make room for an additional laboratory.

The Kristineberg station is amply supplied with reagents and glassware for morphological and experimental work in zoology. It also has five high-grade microscopes of Hartnack, Winkel, and Zeiss patterns, three microtomes and paraffin baths for both petroleum and acetylene burners. It has an excellent photographic apparatus with Goerz lens, on a universal stand devised by Doctor Oestergren for photographing the larger marine invertebrates up to a magnification of three diameters.

It has a library of 5,000 selected volumes and pamphlets dealing with the local fauna or the results of Swedish researches. The library includes that of Prof. Sven Lovén and Prof. Hjalmar Théel, both the gift of the latter to the station. There is also a set of the Zoologischer Anzeiger and the Zoologischer Jahresbericht. In addition the investigator at Kristineberg has at his command the rich collections of scientific literature in the library of the Academy of Sciences in Stockholm, one of the finest scientific libraries of Europe.

Books can be obtained for use at the station from this library on a few days' notice.

The marine equipment of the Kristineberg station is most excellent and complete for biological work. The power yacht *Sven Lovén* (Pl. LII, *B*) is a sturdy motor boat with inclosed cabin, sail, and auxiliary power, well adapted for the work of the station. She is 42 feet long, 16 feet beam, with a draft of only 5 feet with a 20-horse-power petrol motor Columbia, capable of making 7 to 8 knots per hour on a consumption of 5 to 6 liters of fuel. She has reversible propeller blades and a removable screen for use about the propeller while dredging. She also has a removable jib for use when increased sail is needed. A power winch for reeling in the dredging cable can be connected to the engine independently of the propeller. The boat is remarkably steady in the water and the broad deck gives ample room for handling the gear and working the boat. Taken all in all the *Sven Lovén* is a model boat of small size for biological purposes at a biological station, and might well be copied elsewhere. The boat is well equipped with otter trawls of several sizes, fish nets, seines, tow nets, closing nets of Cori and Aurivillius patterns, dredges, trawls, bottom samplers, and reversing thermometers. No extensive hydrographic equipment is to be found at the station, however. The station possesses the rich equipment from the "Gunhild" Expedition of 1877–78, some of it still in serviceable condition. It has a most extensive and practical outfit of hand apparatus for shore and surface collecting of dip nets, scrapers, scoops, grapples, etc. The station also has three small sailboats and several rowboats.

The Kristineberg station enjoys a wide range of environmental conditions. The island belt of the west coast of Sweden, the long fiords that indent the coast for a distance of nearly 40 kilometers, and the much-extended coast line afford the basis for a relatively great development of the littoral fauna. The gneiss and granitic rocks of the shores give a stable attachment for *Fucus* and *Laminaria* zones and in the deeper waters to extensive beds of red seaweeds. Gullmar fiord, near the mouth of which the station is located, is the deepest of the fiords, while the island belt near its mouth abounds in extensive shoals. In places the channels between the islands are narrow, and the rapid tidal currents which prevail here carry food for a rich fauna.

The mean tidal amplitude is only about 30 cm., but in storms at spring tides it may reach 1.5 to 2 m. Owing to the relative steepness of the rocky shores the tide-pool region is not extensive. In shoal parts of the fiords extensive *Zostera* beds and mud flats occur. All types of bottom can be found near the station, rock, cobbles, gravel, sand, and mud, much of the fiord having predominantly mud or

sand. Depths of 50 to 60 m. are found within a kilometer of the station and 142 m. at a distance of 8 km., while in the Skagerrack depths of over 800 m. exist.

The salinity of surface waters varies greatly owing to the relatively large proportions of fresh water contributed by the streams of Sweden. The salinity of Gullmar fiord varies in surface waters from 15 to 30 per mille, while at depths of about 15 m. it is fairly constant at 32 to 34 per mille. The temperatures rise in summer months in surface waters to 16° to 20° C., generally standing at 17° to 18° in July–August. In winter temperatures at the surface nearly reach freezing point, the fiord rarely freezing even in part at Kristineberg.

The fauna of the shores and fiords of Bohuslan is one of the best known in Europe, thanks to the extensive explorations of O. F. Müller, the two Lovéns, Lilljeborg, Bovallius, Malmgren, Malm, Théel, Wirén, Lönnberg, Carlgren, Bergundal, Aurivillius, Oestergren, and Smitt. An excellent summary will be found in Professor Théel's (1907) account of the station. This gives lists of the known fauna in most of the important groups of invertebrates with notes on their local habitats and seasonal distribution. The same paper also gives lists of the species characteristic of a number of localities in the area of the operations of the station.

In spite of the brackish character, at times, of the surface waters, the fauna is characteristically marine, and similar in the main to that of Dröbak and Bergen with fewer oceanic and arctic species. The great extent of the littoral zone affords a rich littoral fauna and contributes a large neritic element to the plankton and also brings a relatively large proportion of larval forms of echinoderms, mollusks, worms, and crustaceans into the plankton. Some idea of the richness of the fauna can be gathered from the fact that about forty species of echinoderms, eleven holothurians, one crinoid, twelve starfishes, eight serpent stars, and nine sea urchins are found in the Kristineberg area. Great shoals of medusæ (*Cyanea*) swarm in the fiords in the summer months. The Chætopoda are very abundant in the mud flats and on the mud bottom of the fiords.

There are a number of fishing boats hailing from both Lysekil and Fiskebäckskil, and Gullman fiord was at one time the scene of a great herring fishery.

The variety of life found in the diverse environmental conditions at Kristineberg affords material in practically all the groups of marine invertebrates, especially of the north temperate and boreal species of the littoral fauna. The investigator will also find at this station water of a high degree of purity and a most excellent field and laboratory equipment for morphological, developmental, or experimental, studies of marine animals.

Literature: Théel (1895, 1907), Bather (1895).

BORNÖ HYDROGRAPHICAL STATION, ON BORNÖ ISLAND, NEAR HOLMA, SWEDEN.

Director, Prof. O. Pettersson, Stokholm, Högskola. At Bornö in summer.

The work of the Swedish section of the International Commission for the Investigation of the Sea is carried on by a Swedish hydrographical commission, which is composed of Professor Pettersson, Dr. F. Trybom, inspector of fisheries, and Dr. G. Ekman, of Gottenborg.

It has its field headquarters in the private laboratory of Professors Pettersson and Ekman, located on Bornö Island near the head of Gullmar fiord, about 16 kilometers northeast of Kristineberg and across the channel from Holma, Professor Pettersson's summer estate. The laboratory may be reached by steamer daily from Lysekil to Holma.

The laboratory is a two and one-half story building, picturesquely located at the water's edge beneath the granite cliffs on the western shore of Bornö Island, commanding a magnificent view of the fiord. In the first or basement floor are the chemical laboratory, machine shop, and storerooms; on the second or main floor, the office and biological laboratory and living quarters of the keeper and staff; and on the third floor, the library, storage loft, and recording instruments for Professor Pettersson's continuous tidal and current registering apparatus. The station is well equipped, in conjunction with the exploring vessel, the *Skagerak*, for hydrographical and plankton work and for experimental work in connection therewith. From the station there is carried into the fiord a double cable railway for the movement of the self-recording current meters, which are so constructed as to keep a continual record of the longitudinal movement of the fiord waters at any desired depth in the channel opposite the station. The same recording instrument also makes a continuous record of tidal changes. The station possesses an excellent library of recent hydrographical literature, and is handsomely equipped with all necessary instruments for its field of investigation. The results of its investigations are published in "Svenska Hydrografisk-biologiska Kommissioners Skrifter" (v. 1–3, 1903–1908).

The building is a private one, leased by the state for the use of the commission. No instruction is given here. The building is used solely by the staff of the station and its facilities are not open for the use of other investigators. The visiting scientist will, however, receive a cordial welcome and find much of great interest in its hydrographical equipment and work.

SWEDISH FRESH-WATER BIOLOGICAL STATION, ANEBODA, SWEDEN.

Director, Dr. Oscar Nordquist, Lund, Sweden.

This recently established station had its origin in connection with the experimental fishing establishment and fisheries school of the Fisheries Society of Southern Sweden (Södra Sveriges Fiskeriförening) and is really the field laboratory of these organizations.

Through the interest of Prof. Gustav Retzius and Doctor Nordquist the Fisheries Society received in 1908 a grant of 4,000 kronen for the purchase of a scientific equipment from the "Lars Hiertas minne," and the first laboratory was opened in the summer of that year in temporary quarters in the rooms of the fisheries school on Lake Stråken. The Swedish Parliament made in the same year a grant of 4,000 kronen for the erection of a building completed for occupancy in 1909.

The station is under the control of the Fisheries Society of Southern Sweden. Its staff consists of a director and an assistant, who are also attached to the experimental fisheries plant and fisheries school of the society at Aneboda. The society makes an annual grant for the upkeep of the station (900 kronen in 1909).

The station is located at Aneboda, about 6 km. from the railway station at Lamhult, on the line between Malmö and Nassjö (Stockholm), in the heart of a district abounding in small lakes. The Fisheries Society maintains at Aneboda, on Lake Stråken, an experimental plant for fish culture consisting of twenty-five artificial ponds of different sizes (in all, 20 hectares), and three lakes (area, 100 hectares), and conducts there a school for fish culturists and lake fishermen.

The building of the biological station is located on a brook near the fish ponds, about one-half kilometer from Lake Stråken. It is situated below the falls in the brook and is supplied constantly with running water for aquaria and cultural purposes. In addition to the director's laboratory the building contains a general laboratory, with places for four investigators, and a fish-culture room. Additional room for two investigators is supplied in the building of the fisheries school.

The laboratory is adequately supplied with microscopes, microtome, thermostat, aquaria, culture basins, etc., and the reagents and chemicals in common use in biological investigations. The field equipment consists of the row boats used at the fisheries school, dredges, plankton nets, Negretti-Zambra thermometers, Pettersson-Nansen water bottle for the conduct of limnological investigations.

Properly qualified students are admitted without fees to the privileges of the station on application to the director, but students from Swedish universities have the first option upon the few available places. The only charges are those for material used.

The station has begun the installation of a collection illustrating the local fauna and the development of fresh-water fishes, and has also started a library of works pertaining to fresh-water fish culture, hydrobiology, and experimental evolution. The lines of investigation undertaken at the station include general limnological problems and the biology of fresh-water fishes.

Literature: Nordquist (1906, 1906a, 1907, 1907a, 1908, 1909).

DANISH BIOLOGICAL STATION.

Central office, biologiske station, Sortedams Dossering 45 A, Copenhagen, Denmark.

Field station, biologiske station, Nyborg, Fyen, Denmark.

Director, Dr. C. G. Joh. Petersen.

The scientific work of the Danish fisheries bureau, inaugurated in 1889 under the "Landbrugsministeriet," is carried on by this station. Its present director, Doctor Petersen, has been in charge of the work from the beginning. Its administration is entirely distinct from that of the inspector of fisheries, which has to do with the legal, commercial, and more distinctly economic phases of the fisheries. The administration is solely in the hands of the director, who is responsible to the minister of agriculture, and the station is independent of all educational alliances. The staff consists of the director and temporary assistants employed in field investigations.

The budget is 25,000 kronen per annum, and of this about 18,000 kronen is used in salaries and pay roll and the remainder in equipment and upkeep of office and field equipment.

The field equipment is located in the sheltered inner harbor at Nyborg, on the eastern shore of the island of Fyen, across the Great Belt from Korsör, about four hours' ride from Copenhagen by rail and steam ferry. It consists of the floating laboratory, the *Biologen Ark*, and the exploring steamer *Hallingsund*. The laboratory was once a naval transport, an iron hull 75 feet in length and 18 in width, with large skylights and entrance at the stern. It provides a shop, store and aquarium room (12 by 18 feet), a large laboratory (18 by 29 feet), a library which also serves as dining room (11 by 14 feet), and five staterooms. The laboratory is fitted with central work table, abundant shelving for ichthyological collections, cases for storage, and a steel tank aquarium for fish, 2.8 m. in length, 1.2 m. wide and 0.9 m. in depth, communicating directly through the bottom of the hull with the sea. The small deck house serves as a tackle room.

The *Hallingsund* is a steel steamer, schooner rigged, 70 feet in length, with beam of 14 feet and draft of 6 feet. She carries a crew of six men and has two staterooms and a small deck laboratory. She is fitted with steam winch and steel cable for dredging and trawling in shallow Danish waters.

The field station has a small equipment for biological laboratory work, a small library on fisheries and local fauna, and a simple equipment of chemicals and glassware. The equipment for field work includes all types of fishing gear used in Danish waters, nets, seines, otter and eel trawls, oyster dredges and rakes, and fish traps of all descriptions. There are also plankton nets, a closing net of the Petersen pattern, for vertical work, Petersen young-fish trawls, and a most efficient type of bottom sampler constructed especially for quantitative study of the bottom fauna.

The central office at Copenhagen has been connected with that of the ichthyological branch of the Danish International Commission for the Investigation of the Sea, and contains working laboratories, ichthyological collections, and small library.

In earlier years some biological instruction was given at the station by the director to students from the university, but in recent years this has been discontinued. The station has no connection with the university and furnishes no biological supplies for educational uses. It also gives no instruction to fishermen. A school, at present on private foundations, for such instruction was opened in 1908 at Kjerteminde by Mag. A. Otterström, formerly assistant at the station. No aquarium is maintained and no hatchery conducted, as the investigations of the director lead him to believe that the hatching of sea fishes is a waste of effort.

The work of the station has in the past been concerned chiefly with the biology of the commercial fishes, principally the plaice and eel and the oyster fisheries. The food, growth, age, local races, transplantation, migrations, and legal protection of the plaice and the effect of the various methods of fishing upon the local stock of fishes and the bottom fauna in general have been investigated, as have also the migration, sexual differences, and local distribution of the sexes of the eel, with reference to legislation for their protection. The effect of submerged electric lights upon the movements of the eel, looking toward the control of the commercial fisheries, has also been the subject of inquiry. The distribution of the plankton and of the bottom fauna has been determined for several typical localities. One of the most important lines of work at this station has been the adaptation of the gear of commercial fishermen to the uses of biological exploration as, notably, in the case of the otter trawl (see Petersen, 1898) and the Petersen young-fish trawl now universally used in marine explorations in Europe.

The station offers no facilities to students or investigators, but those interested in the field work of marine exploration will find much to repay a visit to the Nyborg station.

The results of Doctor Petersen's work have appeared in an irregular series of "Beretning fra der dansk biologiske Station," I–XVII,

1890–1908, included in the annual "Fiskeri Beretning" of the statistical branch of the fisheries bureau. Some of the reports have also appeared as reprints in English.

DANISH FRESH-WATER BIOLOGICAL LABORATORY (OF THE UNIVERSITY OF COPENHAGEN).

Field station located on Füresee near Lyngby (Frederiksdal), Denmark.
Office and laboratory of the director, Slotsgade, Hilleröd, near Copenhagen.
Director, Dr. C. Wesenberg-Lund.
Telegraph address, Wesenberg-Lund, Hilleröd.
Temporary assistants in chemistry, botany, and zoology in summer months.

The Danish fresh-water station owes its origin to the enthusiasm of its present director, whose early investigations upon the fresh-water bryozoans and rotifers opened to him the possibilities of such a station in Danish waters. As assistant in the Veterinary and Agricultural School at Copenhagen in 1898, he secured small grants for the beginning of the station's work in the summer vacation, and in 1900 the enterprise was taken over directly by the Kultus Ministerium, receiving a regular stipend from the state until 1905, when it was transferred to the university as one of its regular departments, with regular annual stipend.

Its administration is entirely in the hands of its director, who in turn is responsible to a committee of the faculty, consisting of Professors Jungersen and Warming, heads, respectively, of the departments of zoology and botany in the university.

Its budget consisted in 1908 of a regular stipend of 5,000 kronen from the university and a special grant of 1,500 kronen from the Carlsberg fund, a fund independent of both state and university, administered in the encouragement of research. It also received a special grant of 4,000 kronen from the university for the purchase of a motor boat. In the past other special grants have been made from time to time for equipment, assistance, and expense of publication, both by the university and the trustees of the Carlsberg fund. The station is thus dependent upon both state and private funds for its equipment and current expenses. The income is spent as follows: Salaries, 1,500 kronen; explorations, assistance, publications, 4,000 kronen.

The work of the director of the station has been carried on in many Danish waters, as well as in others from Iceland and Jan Mayen to the Alps. The present building and equipment are in the main mere temporary adjuncts to his work. The present field headquarters are located upon Füresee, near the old castle of Frederiksdal, not far from Lyngby, and about 23 km. from Copenhagen. It is reached from the city by rail to Lyngby and lake steamer to Frederiksdal.

The present station building is the old deck house of the steamer *Ingolf*, used as a laboratory in the Danish *Ingolf* expedition of 1897. It is a small one-story wooden structure (5 by 5.7 m.) on masonry foundations at the water's edge on the eastern shore of Füresee. It contains three small laboratory rooms, with limited laboratory space for 4 to 6 persons. It is economically furnished with shelving, tables, wall cases, lead-lined aquarium table, and small aquaria with metal or wooden frames. A small tank upon the outside stores a limited water supply drawn from the adjacent lake.

The equipment of the station includes a small supply of glassware and the more commonly used chemicals and reagents, a Krogh CO_2 analysis apparatus, an ample supply of nets and dredges, reversing thermometer and bottom samplers, plankton nets of the Apstein and Fuhrmann models, closing nets of the Nansen pattern, and a new pattern recently devised by Doctor Wesenberg-Lund. The station possesses five microscopes of Zeiss, Leitz, and Seibert make, and microtomes, etc., for preparation work. In addition to row-boats on the several lakes under investigation, the station has a new motor launch *Mysiden*, 22 feet in length, 5½ feet beam, with a 4.6-horsepower "Standard" benzine motor. The boat is equipped with a small hand winch for sounding apparatus, small dredges, and plankton nets, and with a hood and work table for microscopical work on board in the field.

The station is fortunate in the possession of the fine library in the office at Hilleröd, collected by its director, of about 5,000 volumes and pamphlets dealing with limnology, fresh-water fauna and flora, and plankton investigations. The collection is very complete in all phases of the subject. There is also a collection of 4,000 to 5,000 samples of fresh-water plankton, mainly from Danish and European waters. In addition to the facilities at the station itself, the great resources of the laboratories and library of the University of Copenhagen, including as well the library of the Royal Academy, are available for purposes of investigation.

In the past no courses of instruction have been given in connection with the station, but in the future regular courses are to be offered to university students at the station in limnology and plankton problems. Advanced students have, however, resorted to the station every summer to the limit of its capacity for the purpose of carrying on research. The Kultus Ministerium grants annually a sum of 200 kronen, which suffices to pay the summer expenses of four selected students chosen by the biological department of the university in conjunction with the director. No special features are offered to teachers, and the station is in no way directly related to the fisheries or fisheries problems. It has been in the past solely a research station.

Properly qualified investigators will be admitted to such facilities as the station can offer on application to the director without charge. Fresh-water material for investigation is furnished by the station as far as possible on request.

The lines of investigation followed at the station in the past have been faunistic studies of the bryozoans and rotifers, the study of the plankton, especially the seasonal distribution and variation of its constituent organisms, the gases of the lake waters and bottom deposits, the origin and formation of marl and peat both from the biological and chemical standpoints, and the fossil invertebrate fauna of peat formations. The station has control of an interesting series of ponds in the adjacent national forest, which illustrate the several stages of transformation into peat bogs, and is making a complete record of the changes year by year.

The researches of the station have appeared in various scientific journals, and since 1900 the publications of the director form a series of contributions "Dansk ferskvand Biologisk Laboratorium," Op. I–XII. No. V of this series, "Studier over de Danskn Søers Plankton," 1904 and 1905, forms two quarto volumes, with many plates published independently by the Carlsberg fund.

The Danish fresh-water station has little to offer the investigator in the way of an elaborate building, but its record in research, its library collections, and its field operations are exceptional among the fresh-water stations of the world.

Fūresee is a classical locality for a fresh-water biological station, for it was at Frederiksdal, near the site of the present station, that the great Danish naturalist, O. F. Müller, made in the eighteenth century his pioneer explorations into the unknown and marvelous minute life of fresh water. His "Vermium terrestrium," "Würmern süssen u. Salzigen Wassers," "Animalcula infusoria," "Entomostracco," and "Zoologica Danica" all bear evidence to the variety and abundance of forms available in this locality.

Fūresee has an area of 969 hectares and is 40 m. deep. It freezes in January and is open again in March or April. The highest temperature of the surface is about 24° C. The amplitude of the yearly temperature oscillation at the bottom is about 2.8° C. The water is rich in dissolved carbonate of lime. The shores are gently sloping and covered with broad zones of vegetation (*Scirpus-Phragmites* zone, *Potamogeton* zone, *Chara* zone of about 9 m.). The bottom consists of lake marl with rich layers of limonite.

Owing to chalky water the stones and stems of the plants are covered with rich lime deposits. Through the rivulet Mölleau the lake is in communication with many smaller lakes and ponds with greatly different life conditions, and scattered over the country many small isolated ponds and marl pits are found.

The littoral zone abounds in animal life; most all of the littoral animals of the Baltic region are here represented. In the depths of the lake we find the relict fauna of the Baltic lakes, *Mysis relicta*, etc. Diatoms predominate in the plankton in the greater part of the year, but at the highest summer temperatures, *Anabæna* and *Lyngbya* are common. Plankton rotifers and Cladocera are the main forms of the zooplankton.

CENTRAL BUREAU OF THE INTERNATIONAL COMMISSION FOR THE INVESTIGATION OF THE SEA.

(Conseil Permanent International Pour l'Exploration de la Mer.)

General secretary, Commissioner C. F. Drechsel.
Hydrographical assistant, Mr. M. Knudsen.
Biological assistant, Dr. H. M. Kyle.
Office, Jens Koefoedgade 2[1], Copenhagen, Denmark.

This bureau, established in 1902 as the central office, has for its function the coordination of the work of the various governmental bureaus and the publication of their joint investigations. The general business of the commission is conducted through joint meetings of the members of the several bureaus of the different cooperating States at which the programmes of work are outlined and discussed and the reports of committees having charge of joint investigations are discussed and approved before publication. The central office disburses the funds for general administrative purposes and publications only, and for the time, those supporting the central laboratory at Christiania, now discontinued.

The cooperating countries in 1909 are Germany, Belgium, Denmark, Finland, Great Britain and Ireland, Norway, Holland, Russia, and Sweden. The annual budget for 1908–9 was 103,803 kronen.

The publications consist of a series of "Rapports et Procès-Verbaux des Réunions," Vols. I–XI, 1903–1909, a "Bulletin trimestriel des résultats croisières périodiques," Année 1902–3 to 1907–8, 7 volumes to date; a series of "Publications de circonstance," Nos. 1–46, 1903–1909; and a "Bulletin Statistique," vols. 1–3.

The work of the biological assistant is mainly in connection with fishery matters and fisheries statistics. The central bureau is now the source from which the standard sea water is supplied to the cooperating bureaus and others.

DANISH DEEP-SEA COMMISSION.

(Kommissionen for Havundersögelser.)

Chairman, Commissioner C. F. Drechsel. Members: Dr. A. C. Johansen, Mr. Martin Knudsen; Dr. F. Mortensen, inspector of fisheries; Dr. Johs. Schmidt, Dr. C. H. Ostenfeld.

Office, Jens Koefoedgade II[2], Copenhagen.

The operations of the Danish bureau include seasonal cruises to the Faroes and Iceland, the Belts and Kattegat. Especial attention has been given by this bureau to the life history of the eel, to the early stages of the various species of cod, to hydrographic and to plankton work. The publications include a series of "Skrifter" (1904+) and a "Meddelelser" (1904+), with subseries, "Fiskeri Hydrographi, and Plankton," The bureau maintains a fisheries laboratory in charge of Dr. Johs. Schmidt, where the ichthyological work is done. This laboratory contains a remarkably fine collection of the young (pelagic) stages of North Atlantic fish. There is also a plankton laboratory in charge of Prof. C. H. Ostenfeld, and a hydrographical laboratory under Mr. Martin Knudsen equipped for salinity determinations and gas analysis. A specially devised Knudsen water bottle may be seen at this laboratory.

The field equipment of the station consists of the *Thor*, of the English steam-trawler type, a two-masted schooner-rigged steamer of 205 gross (75.6 net) tonnage, length 115 feet, beam 21 feet, draft 14 feet, with triple expansion compound condensing engines of 325 indicated horsepower, capable of making 8 knots per hour on a coal consumption of 6 tons per day. Her bunkers carry 70 tons of coal. She carries a powerful steam winch with 2,000 fathoms of steel cable 1½ inches in circumference for dredging and trawling and has a remarkably efficient equipment of otter trawls for bottom and pelagic work, eel trawls, and Petersen young-fish trawl, pelagic nets, seines, long lines, etc., as well as a complete outfit for plankton and hydrographic work.

Literature: Schmidt (1904).

CHAPTER VIII.

OTHER EUROPEAN COUNTRIES.

HOLLAND.

The tiny country of Holland has maintained since 1876 a vigorous station at Helder, to which was attached, in 1902, the Dutch branch of the International Commission. One of the finest aquaria in Europe, with research features attached thereto, has been maintained at Amsterdam since 1886. Although the pioneer summer seaside laboratory was opened at Ostend by Prof. Van Beneden in 1843, no permanent marine laboratory exists to-day in that country, though a fresh-water station on a private foundation was opened in 1900 by Doctor Rousseau at Overmeire.

STATION OF THE ZOOLOGICAL SOCIETY OF THE NETHERLANDS, HELDER, HOLLAND.

Director, Dr. H. C. Redeke, Het Zoologisch Station der Nederlandsche Dierkundige Vereeniging Helder, Holland.

Assistant director, Dr. J. J. Tesch, Helder, Holland.

In 1875 the Zoological Society of the Netherlands voted unanimously to establish a marine zoological station on the coasts of Holland and appointed a committee consisting of Profs. C. K. Hoffmann, P. P. C. Hoek, and A. A. W. Hubrecht to carry out the enterprise. Being unable to fix upon a site for a permanent location, it was decided to establish for a few years a movable station that could be taken down and re-erected at a new location as seemed desirable. Accordingly a sum of 5,000 florins was raised and in the summer of 1876 a station was opened at Helder, at the mouth of the Zuyder Zee, in a small wooden structure (5 by 8 m.) in which places, with none too ample room, were provided for seven investigators. The building contained a working library, supplied by the society and the Dutch universities, and was equipped with the necessary glassware and chemicals.

For a period of fifteen years the station continued on this basis. The society nominated each year a committee who had charge of the affairs of the station, determined its location, collected and expended the funds, and printed an annual "Jaarverslag" in the "Tijdschrift" of the society, in which the operations of the station were related, the funds were accounted for, and occasional notes on the summer's explorations were placed on record.

The station was opened only during the summer months, was used for research by the zoologists of Holland, and had no permanent

staff. The building was enlarged by the addition of an aquarium (2 by 5 m.) in 1878 and a director's office (2 by 5 m.) in 1880. In 1876 the station was located at Helder; in 1877 at the other end of Holland at Flushing; in 1878–79 at Terschelling; and in 1880 at Nieuwediep. In 1881–1883 it was located at the mouth of the Scheldt and was used in investigations in ostreaculture, returning in 1884 to Flushing and going in 1886 to Delfzyl, in a brackish water bay. In 1886 and 1887 it was again located at Nieuwediep, and in 1887 at Enkhuisen on the brackish Zuyder Zee.

In 1888 Doctor Hoek was appointed counselor to the Government in the matter of the fisheries and became permanent director and resident at the station.

A legacy of 5,000 florins gave the initiative to the construction of a permanent building which was located at Helder and completed in 1889 at a cost of 20,270 florins for building and equipment. Scientific societies and friends of the enterprise contributed 5,250 florins and the balance was secured by loan. The movable laboratory served as an annex for five years, when it was replaced in 1894 by an addition to the building costing 10,000 florins, made possible by a gift of 2,000 florins and a new loan, together with an increased annual allotment from the Government.

In 1902 Doctor Hoek was called to the secretaryship of the newly established International Commission for the Investigation of the Sea at Copenhagen, and the directorship of the station fell to the hands of Dr. H. C. Redeke, its present director.

The Helder station has been from its inception primarily a research institution for the staffs of the zoological departments of the Dutch universities and their research students. It has not undertaken to provide for formal instruction of any grade. It has received from time to time some government aid, and official investigations into questions of the fisheries have been carried on within its walls. Since 1888 its director has been intimately associated with the official fisheries work of the Dutch Government.

Investigations carried on at the station are published in the "Tijdschrift der Neederlandsche Dierkundige Vereeniging," the organ of the society in charge of the station.

The station is supported by annual grants from this society and others in Holland, by private gifts, and small annual grants from the Government or local authorities.

The station is open to members of the society on application to the director, and to other competent investigators when the limited facilities permit. No charge is made for the privileges of the station. Glassware and reagents are supplied, but investigators bring their own instruments. The station is open throughout the year.

Helder is a small city located at the northern extremity of the peninsula of North Holland, at the entrance of the Zuyder Zee. It is reached by rail (61 miles) or by steamer from Amsterdam. The building stands in a small park on the great dike of Nieuwediep. It is a neat stone building of two stories, containing the laboratories and the residence of the director. The original building of cruciform outline with extreme dimensions of 12 by 23 m. has received at one corner a rectangular addition 8 by 16.5 m. The ground floor is given over entirely to the purposes of the station and contains a vestibule (5 by 6 m.), from which a hall leads to the aquarium room (6 by 8 m.), the office (6 by 5 m.) and laboratory (4 by 5 m.) of the director, the library (6 by 8 m.), and the two laboratories (6 by 5 and 4 by 5 m.), and stairs to the director's quarters above. In the wing, in addition to the aquarium room, there are to be found four small rooms serving as storeroom (3 by 3.5 m.), machine room (3 by 5 m.), clerk's office (3 by 4 m.), and service vestibule (4 by 4.5 m.). From this wing stairs lead to two laboratories (each 4.5 by 5 m.) and a storeroom (3 by 3.5 m.) in the second story. Owing to this disposition and arrangement of the rooms and windows in the building the available space for research tables is relatively small, there being room for but five to eight investigators in addition to the director.

The shallow waters and sandy shores of Holland do not afford either the quantity or variety of life that occurs in the tide-swept English Channel or the rocky shores of Normandy. The Helder station is, however, unique in its location at the entrance to a large body of brackish water, the specific gravity of the Zuyder Zee being 1.005 to 1.013, as compared with 1.024 in the North Sea. The great rush of the tidal currents past Helder keeps open a deeper channel to the sea, and provides for a more abundant local fauna upon the rocks of the great dike and the piles of the harbor constructions. In general the marine flora (other than pelagic) is very poor, though Helder is the only point on the coast of Holland where *Laminaria* occurs.

A very full account of the fauna and flora of the Zuyder Zee is to be found in the paper of Van Breeman and Redeke (1908) in the "Zuyder Zee Rapport."

Literature: Hubrecht (1890), Dean (1894), Sand (1897), Dollfuss (1888), Hoek (1885, 1895), MacLeod (1884), and Verslag in the "Tijdschrift" (1876–1908).

DUTCH SEA FISHERIES SCIENTIFIC BUREAU.

Scientific adviser, Dr. P. P. C. Hoek, Haarlem, Holland.

Director, Dr. H. C. Redeke, Ryksinstitut voor het Onderzook der Zee, Het Zoologisch Station, Helder, Holland.

Assistants, Drs. J. J. Tesch, F. Liebert, H. C. Delsman.

Commander, First Lieut. D. A. v. d. Laan.

The Dutch fisheries bureau, in addition to a general scientific adviser in the person of Doctor Hoek, maintains a scientific bureau for the study of the sea (Ryksinstitut voor het Onderzook der Zee) at the Helder zoological station, which is the agency by which the Dutch Government cooperates with the International Commission for the Investigation of the Sea. Two laboratories are maintained—a biological laboratory in the Helder station and a hydrographical one in a small building adjacent to the station. Investigations at sea are carried on in a leased steam tug, adapted by special reconstruction to the needs of the work. The *Wodan* is a paddle-wheel steamer 40 m. long, depth of 3.95 m., and 7.5 m. beam, with a draft, when coaled, of 2.4 m. The compound condensing engines of four cylinders drive the paddle wheels (diameter, 4.8 m.) at a rate of 36 turns per minute. The waist of the vessel is occupied by the large engine room and bunkers (capacity, 75 tons). Behind this are two cabins for the scientific members of the staff, and a third in the poop for the director. The laboratory (3 by 4.5 m.) is placed athwartships immediately behind the bridge, and is well lighted by eight windows and a skylight. It is equipped with zinc-topped worktable along the front wall and lockers for instruments and glassware on the rear wall.

The oceanographical equipment consists of Ekman's, Nansen's, and Pettersson's current meters, Pettersson-Nansen water bottle, Richter thermometers, Fuess barometers, and Assmann anemometers and psychrometers.

The biological equipment consists of a large otter trawl (width of opening, 30 m.) with two dredging cables of galvanized steel (2.625 inches in diameter), each 300 m. in length and made in four parts, connected by patent links. The cables are worked by a steam winch on the forecastle. There are also a small otter trawl, a small beam trawl, and a number of triangular and rectangular dredges. For pelagic work the equipment includes a Hensen vertical quantitative plankton net, a surface "larval" net with a ring 2.25 m. in diameter and bag 10 m. in length, with detachable copper cylinder at end. There is also a "Dutch" net for fish eggs, with ring 1.1 m. in diameter and bag of silk bolting cloth with mesh 0.5 mm. in width.

The budget of the scientific bureau for 1909 was as follows:

	Florins.
Salaries and remuneration	7,400
Hire of vessels, scientific work, etc	17,600
Contribution to International Council for Investigation of the Sea	3,150
Total	28,150

In addition, the general fisheries bureau allots 8,000 florins to scientific and statistical work, not included in the above.

The field of operators of the Dutch division of the International Commission for the Investigation of the Sea is the North Sea south of 54° north, off the coast of Holland. The lines of investigation followed, in addition to the common programme of statistical work and the quarterly cruises, include a study of the movements of marked fishes, the occurrence and distribution of eggs and fry, and the natural history of the flat fishes.

The results of the investigations appear in a Jaarboek (1903+), Vangstatistieken van Hollandische Stoomtrawlers (1903–4+), and a Verhandelingen (1 Deel, 1906; 2, 1909).

AQUARIUM OF THE ROYAL ZOOLOGICAL SOCIETY OF AMSTERDAM ("NATURA ARTIS MAGISTRA").

Director, Dr. C. Kerbert, Aquarium, Jardin Zoologique, Amsterdam, Holland, with five assistants and attendants.

The aquarium of the Royal Zoological Society of Amsterdam, both in its equipment and in its relations to education and research, fulfills many of the functions of a fresh-water and marine biological station. Though it is nearly 50 miles from the open sea at Helder, marine aquaria of an excellence unsurpassed in northern Europe are maintained in it throughout the year in a high state of efficiency.

The aquarium was developed in connection with the zoological gardens which are maintained by the Royal Zoological Society of Amsterdam, a private organization of large membership (4,200) and an annual income of 200,000 guilders. Members are admitted to the aquarium, which is not open to the public, though foreigners are admitted to this privilege upon payment of 3 guilders ($1.20).

Grounds of an area of 10 hectares, costing $185,000, were secured in 1877, and the building was completed in 1882, at an expense of about $160,000.

The ground for the aquarium building was ceded by the city on condition that provision be made for the zoological laboratories of the university. Provision is accordingly made for a lecture room and laboratories and ample space for a zoological museum. Students are permitted under certain restrictions to make use of the facilities afforded by the zoological garden and aquarium for study and research. No formal provision is made for investigators not members of the university.

The results of the scientific investigations of the zoological society, including the results from the garden and aquarium, are published in the "Bydragen tot de Dierkunde," an illustrated quarto series (1848+).

The aquarium is in the eastern part of the city and stands at the southeast corner of the zoological gardens on the "Middenlaan." The building is a masonry structure of two stories, resting upon 1,740 piles. It stands in grounds with an area of 2,735 sq. m., and has

extreme dimensions of 29 by 87 m. In the basement or lower story (Pl. LV, figs. 1 and 2) are the three long reservoirs (*b*, *b'*, fig. 1) for sea water, with a capacity of 116 cu. m., together with the service passages, filters, and machine room.

On the main floor (second story) (Pl. LV, fig. 3) is a long central hall (*A*) (6 by 40 m.) with twenty exhibition tanks ranged along the two long sides. This room is lighted through the aquaria solely. Ventilation is provided by circular windows of red glass, which admit but little light, in the vaulted roof. The hall is entered through a handsome portico (*C* and *Y*) from which open the office (*K*) and laboratory (*G*) of the director, the office (*H*) of the custodian, store-room (*I*), the workrooms (*E*, *F*) for the personnel, and the service corridors (*D*, *D*), 1.8 m. in width, entered from the service rooms or from the lower floor.

At the far end of the main hall is the entrance into the room (*B*) (10 by 16 m.) for research aquaria. A semicircular projection at the end of the building provides for a circular lecture hall (*M*), 12 m. in diameter, with adjacent laboratories (*N*, *N*, *O*), and offices (*P*, *Q*) occupied by the zoological department of the university. Upon the long façade of the building is a second portal (*C*), which leads to the three museum rooms (*L*, *L*, *L*).

Great care has been taken in the plan and construction of this, one of the largest and most costly of the aquaria of Europe. The exhibition tanks (*a*) rest upon arches (fig. 3) of solid masonry and are themselves placed between the pillars of superposed arches of the upper floor. The walls of the tanks are of massive brick work (0.65 m. thick), are lined with cement, and provided with rock-work backs.

Upon the left-hand side of the hall are nine tanks of sea water (total capacity 85 cu. m.) and upon the right eleven (total capacity 61 cu. m.) for fresh water. In all, five sizes of tanks are used, the inside dimensions of which in meters are given in the accompanying table:

Numbers.	Length.	Width.	Height.	Depth of water.
5	8.95	2.41	1.88	1.73
1, 4, 6, 9, 10, 13, 17, 20	2.11	1.92	1.63	1.23
2, 3, 7, 8, 11, 12, 18, 19	2.91	1.92	1.63	1.54
15	2.89	1.90	1.63	1.54
14, 16	2.73	1.92	1.60	1.20

These tanks are abundantly illuminated by oblique overhead windows and are glazed with plate glass fitted to the masonry front, resting against rubber blocks and set in minium cement. The dimensions of the glazed openings vary according to the tank, the lengths ranging from 1.25 to 2.75 m. and the thickness from 25 to

48 mm. Each opening has a ledge about 0.5 m. wide upon which labels are placed and a curtain which may be lowered when the tanks are undergoing repairs or being cleaned.

In addition to exhibition tanks there are thirteen smaller unglazed tanks (R 1–*R* 13) which serve for the storage of reserve animals or for those which are in the process of acclimatization to life in aquaria or for those which have been withdrawn by reason of their unhealthy condition. Of these, nine (capacity 13 cu. m.) are for sea water and four (capacity 9 cu. m.) for fresh water.

In the smaller aquarium room are twenty tank aquaria upon tables and sixteen aquaria vessels. All are richly supplied with vegetation and a number are so piped that they may be connected with the circulating system if necessary; but in the main they are not circulating aquaria. Two large aquaria and a number of smaller ones are used for smaller marine animals and the remainder as fresh-water aquaria. Four of the large and five of the smaller aquaria are kept warm by hot-water pipes beneath them and at a constant temperature by means of thermoregulators (system of Professor Weber). In these aquaria are kept tropical fishes from India, China, and South America.

The central aquarium is a hexagonal basin 2.3 m. in diameter and 0.45 m. in depth, with a capacity of 3 cu. m. and a central fountain. There are also four fresh-water aquaria (76 by 150 by 48 cm.) with a capacity of 552 liters and smaller ones (53 by 95 by 45 cm.) holding 227 liters. These aquaria have brass frames and are covered with frames of wire netting.

The salt-water supply is taken at a considerable distance from shore in the open sea and is shipped to Amsterdam in wooden casks. About 50 cu. m. is added yearly to the supply to make up for waste and loss, the total stock on hand being about 600 cu. m. The pumping plant is in duplicate. The water is pumped by a Babbitt metal pump driven by a 4-horsepower gas engine, to the reservoirs on the third floor. These reservoirs have a capacity of 20 cu. m. They are of iron lined with asphaltum. The water is distributed thence in 19 cm. mains of enameled iron with flange joints and laterals of glass and rubber. Pipe joints and fittings are set in melted sulphur.

The water is delivered from glass tips by overhead spray to the aquaria. The outflow is by a surface orifice at the rear of the tank discharging into earthen-ware pipes encased in masonry shafts on the rear face of the tanks. These discharge into open iron troughs coated with asphaltum, which carry the water to the filters. Each tank is provided with a bottom clean-out, discharging through a 4 cm. asphalted cast-iron pipe, with hard-rubber valve.

FIG. 1

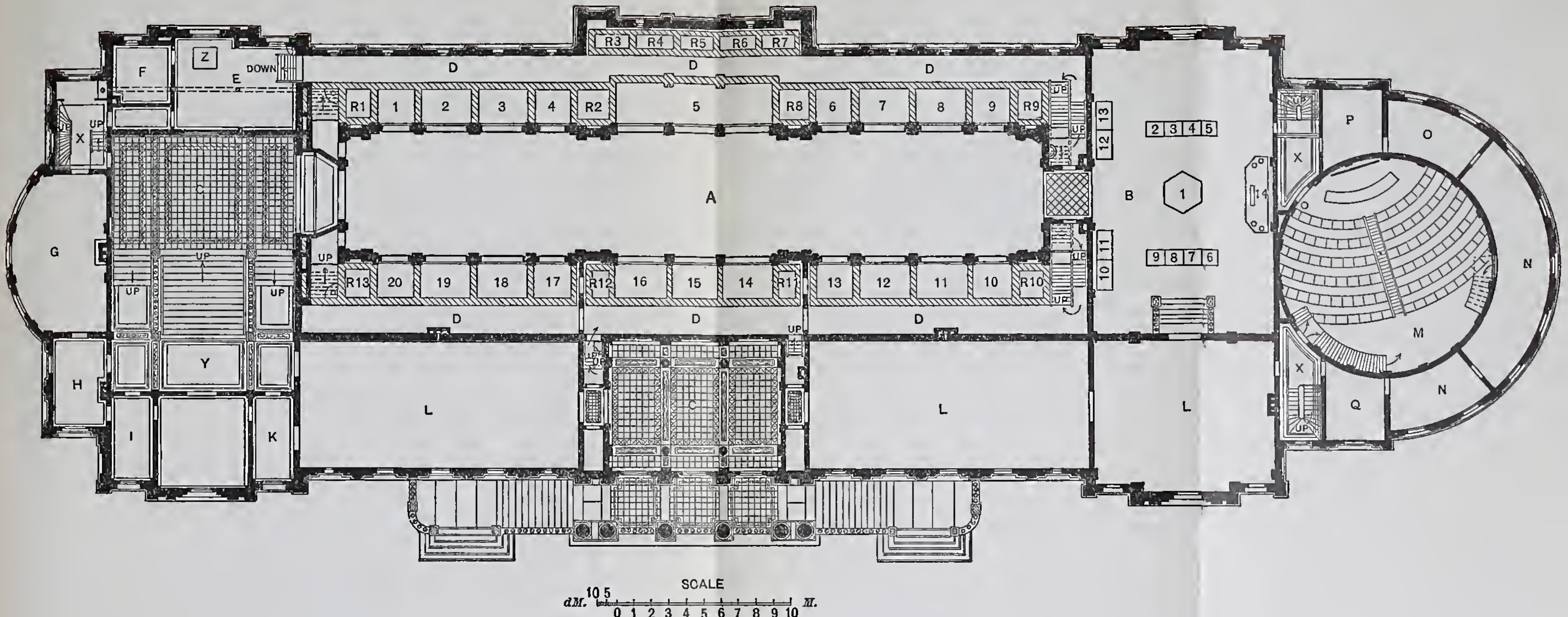


FIG. 1.—FLOOR PLAN.

FIG. 2

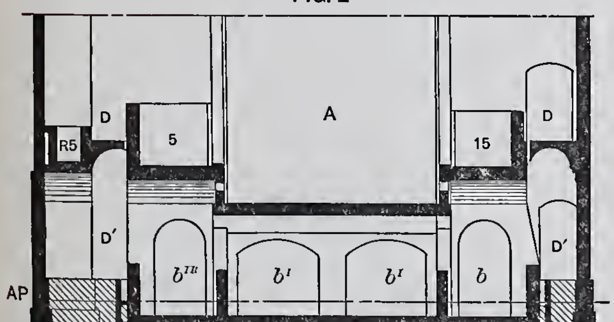


FIG. 2.—CROSS SECTION THROUGH MAIN AQUARIUM ROOM AND BASEMENT.

FIG. 3.

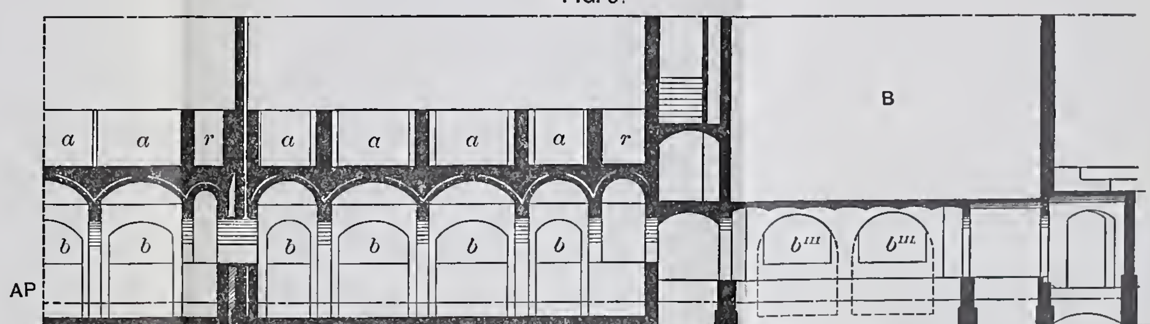


FIG. 3.—LONGITUDINAL SECTION THROUGH AQUARIUM TANKS AND SMALL AQUARIUM ROOM.

A, Main aquarium room with 20 peripheral tanks (1–20). B, Small aquarium room with 14 table aquaria. C, Vestibules. D, Service corridors. E, Workrooms for aquaria. F, Keeper's room. G, Laboratory of chief conservator. H, Office of custodian. I, Stoves. K, Office of conservator. L, Museum. M, Auditorium. N, Laboratories. O, P, Q, Laboratory and offices of instructors. X, Entrances to laboratories. Z, Elevator. 1–9, Salt-water tanks. 10–20, Fresh-water tanks. R (1–13), Reserve tanks.

PLANS OF AMSTERDAM AQUARIUM.

From the aquaria the water passes to the filter beds above the great reservoir tanks. These are of heavy wooden planking and contain a layer of stones with gravel and sand (20 cm.) above. The filters are in duplicate, but one being used at a time. With the purpose of permitting a complete sedimentation and fermentation of the water the reservoirs and filters are so constructed that the filters discharge at one end of a long reservoir. Surface water only is drawn off at the other end and the water passes thence through a second long reservoir before reaching the intake of the pump.

The salt-water system is thus a closed one. The fresh water, on the other hand, after sedimenting in the long reservoir is passed through the aquaria and discharged to the sewer after use.

The aquaria are amply stocked, a collection being kept at Helder for this purpose. Shipments are made in wooden tanks (0.9 high, 0.75 m. diameter) with reduced opening.

In addition to an extensive assortment of mollusks, arthropods, worms, echinoderms, sea anemones, and other cœlenterates from the coasts of the Netherlands and the English Channel, the aquarium keeps constantly on exhibition an extensive variety of fishes fresh-water and marine, tropical and exotic, as well as the native ones.

Among the notable achievements of Doctor Kerbert have been the successful installation of a herring tank (pelagic fish being notoriously difficult to handle in aquaria), the rearing in captivity of a number of fishes, and especially the breeding in the tanks of the giant salamander of Japan.

Literature: Kerbert (1888, 1905, 1906), Hoek (1895).

BELGIUM.

BELGIAN FRESH-WATER BIOLOGICAL LABORATORY, OVERMEIRE, BELGIUM.

Director, Dr. Ernest Rousseau, 31, Rue Vautier, Bruxelles, Belgium.

The "Station biologique d'Overmeire" was opened in April, 1906, under the directorship of Dr. Ernest Rousseau, to whose efforts its foundation was due. Commissioned by the Royal Museum of Natural History of Brussels to conduct an exploration of the fauna of the fresh waters of the country, he became convinced of the desirability of a fresh-water station and finally selected a location in "lower" Belgium, upon Lake Overmeire, as the most favorable situation, both on account of the richness of the local fauna and of the accessibility from scientific centers of the country.

The station is a private venture established and equipped by the director and has no organic connection with the universities or scientific institutions of Belgium.

There small size and slender resources of the station limit its facilities.

The are, however, two research tables which are offered without

charge, except for reagents used, to competent investigators upon application to the director. The station does not supply microscopes or microtomes.

The programme of the station as outlined by the director includes from the scientific point of view (1) a qualitative analysis of the local fauna and flora and the formation of a representative collection which shall become the property of the State; (2) a quantitative inventory of the characteristic assemblages which define the types of local fauna and flora; (3) an investigation of environmental conditions with a view to determining the influence which they exercise upon the fauna and flora; and (4) contributions to the anatomy, development, and classification of the organisms of fresh water.

From the educational standpoint, it is proposed to assist in scientific instruction and the cultivation of popular interest in the biology of fresh waters by lectures, excursions, and supplying of biological materials to universities and schools, but not by formal courses.

From the economic standpoint, the programme includes the study of the destruction of fisheries by overfishing and diseases, the introduction of new fish, the augmentation of returns from fish culture, and the development of a scientific fish culture with hope of creating a national school and bureau of pisciculture.

The director of the station is editor of the "Annales de Biologie Lacustre," an international journal of hydrobiology, and much of the scientific work done at the station appears in this journal. The lines of investigation thus far published are mainly faunistic.

The Overmeire station is located in Flanders, northeast of Brussels. It is two hours by rail from Brussels, Louvain, and d'Anvers and an hour and a half from Ghent, near the commune of Overmeire in the country of Waes, the "garden spot of Belgium."

The building, the "Chalet Prince Albert" at the water's edge of the northeast shore of Lake Overmeire, is a two and one-half story dwelling of brick, adapted to the uses of a biological station, the form of the structure and the ample windows lending themselves admirably to the purpose. On the ground floor are an aquarium room, a tackle room, a cloakroom and two small laboratories, and on the floor above, the ample and completely furnished library, a collection room, a photographic dark room, and two private rooms.

The station is simply but effectively equipped with the necessary laboratory furniture, with glassware, chemicals, and reagents necessary for limnological work.

In the aquarium room adjacent to the laboratory are fifteen large aquaria fed by a reservoir located on the terrace of the floor above, with a capacity sufficient to renew the water in the aquaria twice daily. A hand pump is attached to the reservoir which is filled with water from the lake. The station is equipped with several small

boats, including a sail boat and an ample supply of collecting apparatus, including Apstein plankton nets, dredges, tow nets, thermometers, etc.

The library contains several hundred volumes, including reprints from many limnologists and sets of the publications devoted to this subject. The museum is intended to represent the local fauna and flora in full, and visiting specialists are asked to contribute authentically named material to its collections.

The Overmeire station is located in a region rich in ponds, marshes, and swamps, on an ancient arm of the river Scheldt, the largest lake in Belgium, originally 18 km. in length, but now much reduced by reclamation works. It communicates by a small canal with the Scheldt, whose lower reaches, an hour distant by train, afford transitions to brackish and salt water, especially in the adjacent creeks and marshes. The fauna and flora of ponds, marsh, swamp, lake, river, and brackish water are thus accessible from this station.

Literature: Rousseau (1906, 1906a).

SPAIN.

There are two stations on Spanish coasts, one at Santander (1886) on the shores of the Bay of Biscay, and one recently opened at Palma, Balearic Islands, in affiliation with the Museum of Natural Sciences at Madrid.

MARINE BIOLOGICAL STATION AT SANTANDER.

(Estacion de Biologica Maritima.)

Director, Prof. José Rioja y Martin.
Ayudante, Luis Alaejos y Sanz.

Founded in 1886 by the present director. It has an annual budget of 15,000 pesetas. It is not directly attached to any educational institution.

Literature: Rioja y Martin (1906).

MARINE ZOOLOGICAL LABORATORY AT PALMA, MAJORCA, BALEARIC ISLANDS.

Director, Professor Odón-de-Buén y del Cos, Gabinete de Zoologia, Universidad, Barcelona, Spain.
Assistant, Doctor Fuset, Lycée, Palma, Majorca, Spain.

The station at Banyuls and the cordial relations which always existed between its founder and the University of Barcelona in Spain were instrumental in bringing about the establishment of a station in Spanish territory. The efforts of Doctor Odón-de-Buén, professor of zoology at Barcelona, to interest the Spanish authorities in the matter were crowned with success in 1906, when a decree of the minister of public instruction established the station and named him as its director.

The station is a national one, an annex of the Museum of Natural Sciences at Madrid. It receives an annual subvention of 41,000 pesetas, of which 10,000 are received from the ministry of agriculture, and the balance from the ministry of public instruction. Small sums are also granted by the local and provincial authorities.

The station is open throughout the year and its facilities are granted without charge to investigators and students of all lands, upon application to the director. It maintains a biological supply department, furnishing living animals to Spanish universities and to others upon application. It is primarily an institution for research in marine biology, but oceanographic investigations and the culture of marine animals are both included in its projected development.

The station is located on the south coast of the island of Majorca on the bay of Porto-Pi on the Gulf of Palma, about 4 km. southwest of the city of Palma, in a region of villas. A tramway connects the suburbs with Palma, a city of 70,000 inhabitants. Palma is connected by daily steamers (twelve hours) with mainland at Barcelona and by weekly steamers with Marseille and Algiers.

The building stands on the south shore near the head of the bay of Porto-Pi on the water front. It is a two-story villa remodeled for laboratory purposes with garden and a detached aquarium building below the terrace opening upon the street. Photographic dark room and reservoirs for sea water are also located in detached buildings in the garden.

Upon the ground floor are the vestibule, director's office, library, chemical room, and three small laboratories. In the second story are found a large central room with shelving for glassware and collections and places for two workers, and adjacent to it five cubicals, each equipped for a single person. Each private laboratory is equipped with a horseshoe-shaped table, with central revolving chair, cupboard for material, and shelving and cases for reagents, and is provided with electric light and tap for fresh or salt water.

Beneath the terrace in front of the laboratory and opening directly upon the street below, almost at sea level, is the aquarium building, with a room adjacent for receiving, storing, and shipping the collections and another used as a tackle and machine room. The aquarium room (6 by 13 m.) is lighted by windows on the street face and has upon the other three walls eight cement tanks each with glass (0.5 by 1.5 m.). The tanks open directly into the room and receive zenithal illumination. The different aquaria are arranged to represent different types of bottom in the Balearic plateau, calcareous, silicious, and volcanic rocks, *Lithothamnion* nodules and calcareous and granitic sands. The rich fauna exhibited in the aquaria is quite similar to that shown at Banyuls.

The water supply is admitted by a sea pipe to a subterranean reservoir hollowed out in the calcareous rock below tide level and lined with cement to prevent seepage or infiltration. After sedimentation and cooling, it is pumped to five reservoirs of reenforced concrete on the terrace above with a total capacity of 20 cu. m., sufficient for a day's supply to the aquaria. The pump is driven by a 1-horsepower electric motor. The aquaria are supplied and aerated by simple overhead jets and the water is used but once.

The station at Palma has as yet only the beginnings of a library and museum. Its instrumental equipment is modern and excellent, including Reichert microscopes with one-twelfth and one-sixteenth immersion objectives, Zeiss binocular, dissecting microscopes with Porro objectives, Abbe cameras, Adnet ovens, etc. If necessary visiting naturalists are supplied, as far as the equipment permits, with their instrumental outfit. Arrangements should be concluded in advance with the director by those wishing to use the microscopes of the station.

The station is provided with two sailboats, the *Lacaze-Duthiers* of 9 tons with captain and four sailors. The boat is large enough to make trips to adjacent coasts of the Mediterranean. The *Bolivar I* is somewhat smaller and will be equipped with auxiliary motor for pelagic collecting and shore excursions. The station also has a rowboat and a folding canoe for exploration of the grottoes and subterranean waters which are found in Majorca. The steamer *Cabrera* of 80 tons is utilized for explorations in deeper waters beyond the edge of the Balearic plateau. The marine equipment includes a large trawl, bottom and pelagic nets, dredges, traps, coral tangles, etc.

The sheltered harbor of Porto-Pi affords a safe collecting ground under almost all conditions of weather, and the Bay of Parma with its varied shores and wide range in depths and character of the bottom brings a rich and diversified fauna and flora within easy reach of the investigator at the station. An accessory station is projected at Algeciras on the African coast.

The station at Palma promises to be an efficient instrument in the development of research and in the diffusion of scientific knowledge and in the growth of interest in science among Spanish peoples.

Literature: Odón-de-Buén (1908).

FINLAND.

The biological stations in Finland owe their existence primarily to educational and research motives. in the case at least of the summer zoological station in Esbo-Lofo (1889) associated with the zoological department of the University of Helsingfors. Economic interests have been more or less operative in the case of the fisheries experiment station at Evoïs (1892) and in the foundation of the hydro-

graphical-biological commission (1902) which carries Finland's part in the work of the International Commission for the Investigation of the Sea.

FINLAND FISHERIES EXPERIMENT STATION, EVOÏS, FINLAND.

Director, J. A. Sandman, fisheries inspector, Helsingfors, Finland.
Resident director, Förster A. Arimo, Evoïs, Finland.

This fisheries station is located about 50 km. northeast of the city of Tavastchus near the Forestry Institute of Evoïs, in the midst of a district of many small lakes utilized in culture experiments. The station was established on public funds in 1892 by Dr. Oscar Nordquist, at that time fisheries inspector for Finland. Its main function is that of practical fish culture, but in connection therewith under the direction of Forester Bernhard Ericsson, the director of the station from 1892 to 1907, systematic work was carried on upon the life of Finnish fresh waters.

Since 1901 a fisheries school has been established in connection with the station where a few pupils are instructed yearly in the practice of pisciculture. Annual reports of the work of the station appear in the "Fiskeri Tidschrift for Finland."

Literature: Ericsson (1902), Levander (1906a, 1906b), Seligo (1897).

SUMMER ZOOLOGICAL STATION, ESBO-LOFO, FINLAND.

Director Dr. K. M. Levander, zoological laboratory, University of Helsingfors.

In the period 1889–1900 Professor Palmén established and maintained on the island of Esbo-Lofo, 11 km. southwest of Helsingfors, a summer zoological station equipped with microscopes, glassware, and reagents from the zoological laboratory of the university at Helsingfors and lodged in temporary quarters under the direction of Dr. K. M. Levander, widely known for his investigations on the biology of fresh waters. The field of operations was a series of fresh-water lakes adjacent to the laboratory. This station was resorted to by advanced students and teachers for instruction and research. The results have appeared in the "Acta Societatis pro Fauna et Flora Fennica" in a number of important contributions dealing with the fauna of fresh water, parasites of fishes, noteworthy for their extent and comprehensive character.

Literature: Palmén (1893).

HYDROGRAPHICAL-BIOLOGICAL COMMISSION OF FINLAND FOR THE INTERNATIONAL INVESTIGATION OF THE SEA.

Central office and laboratory, Konstatinskatan 8, Helsingfors, Finland.

Members, all from Helsingfors, Finland: K. F. Slotte, professor of physics, Technische Hochschule; Th. Homén, professor of physics, University, director of hydrographic investigation; G. Melander,

director of the Meteorological Bureau; J. A. Sandman, fisheries inspector, director of fisheries investigations; K. M. Levander, docent in zoology, University, director of plankton investigations.

Assistants: Rolf Witting, assistant in hydrography; H. M. Palomaa, chemist; Sigmund Stenius, assistant chemist.

The Finnish commission was established in 1902 in cooperation with the International Commission at Copenhagen and has for its field of operations the Baltic Sea north of 59° north, including the gulfs of Bothnia and Finland. Its field is peculiar in that it contains the waters of less salinity than any other included in the area of the "International investigations" and closed to navigation during a part of the year.

The special fields of investigation undertaken by the Finnish bureau are largely determined by these peculiar hydrographic conditions. They include an analysis of the hydrographic conditions, with especial reference to the local and seasonal variations in salinity and relations of these factors to the circulation of the Baltic and to the distribution of food fishes (plaice, spratt, cod), bottom life, and plankton. The results of the work appear in the "Finlandische hydrographische-biologische Untersuchungen," a quarto series of which two numbers have (1908) appeared.

The hydrographical and biological results of the quarterly cruises (May, August, November) appear in the "Bulletin" of the central bureau at Copenhagen.

The explorations of the commission are carried on in the *Nautilus* (home port Helsingfors), a kedge-rigged steel steamer specially built for the work. She has a length of 29 m., beam 6.1 m., draft 2.68 m., and gross tonnage of 150 tons. She has triple compound condensing engines of 325 indicated horsepower and a speed of 10 knots an hour. There is a dynamo for electric lighting and a steam winch forward with hoisting power of 3,000 km. for dredging and trawling, with 1,000 meters of galvanized-steel cable 11.8 mm. in diameter with breaking strain of 7,500 km. and 400 m. of cable 3 mm. in diameter for hydrographic work and small plankton nets. The cost of the vessel was 144,759 Finnish marks ($28,952). The boat carries a scientific staff of three, and the officers and crew number thirteen. The laboratory (2.7 by 2.8 m.) is located forward and has working places for several persons. It is fitted with tables for peripheral laboratory table and racks and cases for instruments and collections.

The boat is equipped with an English otter trawl, nets, seines, and hand lines for fisheries work, plankton nets, and the international instruments for hydrographic investigations, including the Pettersson bifilar current meter. A unique feature of the equipment is an electric bifilar current meter devised by Doctor Witting (1905, 1908).

Literature: Homén (1907), Witting (1908).

RUSSIA.

Although lacking favorable shores for marine work, Russia has not failed to make good use of such opportunities as she has, for in addition to the Russian station at Villefranche she has two marine stations on her own shores, one in the south at Sebastopol (1871), one of the pioneer stations of Europe, and a second in the far north at Alexandrovsk (1899), the successor of the earlier station at Solowetsky (1881), the most northern station in the world. On these same coasts the Russian International Commission (1902) has also established a fisheries field station. With her great extent of rivers and many lakes, it is natural that Russia should have several fresh-water stations. At Lake Bologoe (1897) and later on Lake Seligner Professor Borodin has maintained a summer station, and the Moscow Fisheries Society has also conducted a similar station at Lake Glubokoje (1888), near Moscow, and the Saratov Natural History Society has maintained a station on the Volga since 1900. A fisheries station at Nikolsk is attached to the Russian fisheries bureau.

BIOLOGICAL STATION OF THE IMPERIAL ACADEMY OF SCIENCES OF ST. PETERSBURG, AT SEBASTOPOL, CRIMEA, RUSSIA.

Director, Academician W. W. Zalensky, Imperial Academy of Sciences, St. Petersburg, Russia.

Superintendent and chief zoologist, Dr. S. A. Zernoff, biological station, Sebastopol, Crimea, Russia.

Assistant zoologist, Miss L. J. Jakuboff.

In addition, one machinist, two collectors, and a laboratory servant.

The Sebastopol station was founded in 1871 by the Imperial Academy of Sciences largely through the influence of Prof. A. Kovalevsky, who was for many years its director. In 1897 a new building was erected with ample modern conveniences and enlarged resources. The station is the property of the Imperial Academy of Sciences, by whose zoological section it is controlled. It is supported by state funds received through the academy and shares the official privileges of governmental institutions. Its director is a resident member of the academy at St. Petersburg, and the immediate control of the station is in the hands of a resident superintendent, who is also chief zoologist of the station. An assistant zoologist has charge of laboratory details. An annual report is made of the station's activities to the Academy of Sciences.

The station receives an annual stipend of 6,700 rubles (to be increased to 16,100 rubles in 1910) and the further income from the sale of collections to museums and institutions of learning in Russia and from admissions to the aquarium. Of the income, 4,460 rubles are expended for salaries and labor and 2,240 rubles for upkeep.

The station conducts no courses of instruction and is not related to the fisheries. It is primarily and solely a research institution,

open throughout the year, and offering its facilities without charge to competent investigators. Preference is given in the following order to applicants: Members of academy, professors, and graduates in Russian universities and institutions of higher learning in natural sciences and medicine, foreign scholars, Russian students, and publishing investigators regardless of academic standing. Applications are made to the officers in charge. Investigators are supplied with material, common reagents, glassware, and service, but bring their own instruments. Expensive reagents, laboratory supplies, and breakage are charged at cost.

Collections of living and preserved marine material are supplied to Russian universities, museums, and schools for instruction and research on payment of charges. List on application.

The results of investigations carried on at the station are printed in part in the regular series of the Imperial Academy with the special title "Travaux du laboratoire zoologique et du Station Biologique du Sebastopol." Fifteen numbers of this series have appeared.

The station is located in the suburbs of Sebastopol on the marine boulevard on the eastern shore of Atellerieskie Bay, near the entrance of the naval harbor. It lies on a small plat of ground (about 800 sq. m.) against the low cliff, and its main façade faces the northwest. It is a three-story building (11 by 30 m.) in the French renaissance style, with a seaward projection (7.5 by 10 m.) of one story containing the aquarium and two towers containing the water tanks. The walled court surrounding the building contains the quarters of the assistant zoologist and machinist, the water tank, storerooms, fish room, machine shop and smithy, and boat ways.

On the first basement floor are the exhibition aquarium room (7.5 by 10 m.), shipping, tackle, and store rooms, servants' quarters, and gas room, with "Excelsior" gasoline apparatus, which furnishes gas for lighting and laboratory use.

On the second floor is the general laboratory (5 by 9 m.), a reagent and glassware room (3 by 5 m.), a dark room equipped for photographic work, and seven small laboratories ranging in size from 3 by 5 to 1.5 by 3 m. On the third floor is the library (5 by 9 m.) and the quarters of the director and superintendent. In all there are seventeen tables for investigators or students and three for the staff.

There are fifteen aquaria in the exhibition room of various sizes, the largest being 2 m. long, 1 m. high, and 1.1 m. wide. The glass is set in iron frames and the walls and floors are of well-burnt brick laid in cement and faced with natural rock. A central basin has a depth of 1.5 m. and a capacity of 22 cu. m. The aquarium is built in grotto fashion with aquaria lighted by side windows immediately above them. Curtains shut off the light above the aquaria, and access for attendance is from the aquarium room itself.

The circulatory system is closed. The water is pumped by a 3-horsepower electric motor, with a 2-horsepower gas engine with pump in reserve. The total capacity of the aquaria is 24 cu. m. The water passes from the cement reservoirs in the towers or in the large reservoir in the court (6 by 8 by 2 m.), with walls 0.66 m. thick, to the aquaria, thence through sand filters beneath each aquarium to the central basin, whence the water is returned to the reservoirs. The water is changed in the aquaria twice daily and renewed in the reservoirs every two to three weeks or in bad weather every two months. The laboratory circulation uses fresh sea water and is independent of that of the aquaria.

The station is heated by stoves, has electric light, gas, fresh and salt water, and a Semper's compressed air system.

The instrumental equipment of the station is extensive, including thermostats, nine microscopes (five high-grade of Zeiss, Seibert, and Nachet), a Schultze horizontal microscope for use with micro-aquaria, eight microtomes (of Jung and Minot-Zimmermann), and two microphotographic outfits. The station is not equipped for physiological, bacteriological, or hydrographic work.

The library is most excellent, having been augmented by that of its former director, Professor Kovalevsky. It contains 5,719 volumes, in addition to the journals, of which 97 are currently received.

The field equipment consists of the sloop *Alexander Kovalevsky*, 36 feet long, 10 feet 3 inches wide, 2 feet 6 inches draft, 7 feet 7 inches depth, of 6 tons, fitted with "Wolverine" motor as auxiliary power, capable of giving a speed of 6 km. per hour. There are also several smaller sail and row boats. The station is equipped with dredges, beam trawls, Apstein and Müller plankton nets, and a plankton trawl.

In the neighborhood of Sebastopol are many sheltered bays permitting collection at all times. The depths in the region of Sebastopol are 20 to 40 m. At depths exceeding 100 m. the waters of the Black Sea are stagnant, heavily charged with hydrogen sulphide, and barren of life. The shore, bottom, and pelagic fauna above this level (see papers by Sowinsky (1902) and Zernoff (1908)) is abundant, but not as rich as that of the Mediterranean.

Literature: Ostroumoff (1892), Zernoff (1905, 1908, 1908a).

RUSSIAN MARINE BIOLOGICAL STATION ON THE MURMAN COAST.

Alexandrovsk, Gouv. Archangelsk, Russia.

Director, Prof. Dr. W. Schimkewitsch, Zoological Laboratory, Imperial University, St. Petersburg, Russia.

Resident superintendent, Dr. Herman Klüge.

In addition, one assistant, one preparator, and several servants.

The explorations of Wagner and Meereschowsky in the White Sea in 1870–1880, revealing there an abundant fauna, the general interest

in that decade in biological stations, and especially the example of the Sebastopol station, led the biologists of St. Petersburg to interest themselves in one upon the shores of the Arctic Ocean. Under the leadership of Prof. N. P. Wagner, and after years of agitation, a station was finally opened in 1881 on the island of Solovetsky in the White Sea near Archangel, on the premises of the ancient monastery of Solovetsky, largely through the aid of the archimandrite Melete of that institution, who reconstructed a building for the use of the enterprise.

The station became the arctic Mecca for students and investigators in zoology from the University of St. Petersburg and was opened in the summer of each year (with few exceptions). Its support came in part from the ministry of public instruction and in part from the treasury of the Imperial Society of Naturalists of St. Petersburg, which includes in its membership the supporters and patrons of the enterprise.

In 1899 the station was moved to Alexandrovsk, on the Murman coast, and a special building constructed. In 1904 Dr. S. Averinzev was appointed as the first resident director, and the station was from that time kept open throughout the year. In 1908, after four years of strenuous effort in which the station was enlarged and equipped and a preliminary survey made of the local fauna, he retired from the post and was succeeded by Doctor Klüge.

In 1904 the station received for the first time a substantial grant from the Government (15,000 rubles) for building and equipment and an annual stipend of 8,500 rubles for maintenance.

The affairs of the station are in the hands of a commission of eight persons, members of the Royal Society of Naturalists of St. Petersburg, the chairman of the commission, Professor Schirnkewitsch, being the director of the station.

The station has been devoted from its inception to research, no formal instruction and no direct connection with fisheries investigations having been established. The station is open throughout the year, but the arctic winter and the polar night which continues for two months at the latitude of the station (69° 13′ north) make work impracticable during the colder months. The favorable season is from April to September.

The station is open without charge to all competent investigators, who should apply to the commission through the director for the permission to occupy a table at the station. Chemicals (except more expensive reagents), glassware, material for investigation, as far as it is available, a separate cubical equipped for investigations, and a furnished sleeping room are provided for investigators at the station. Microscopes are not furnished, but the station offers the use of a Sar-

torius paraffin oven and a Jung microtome. Pension is provided in the station at a monthly rate of 40 to 50 rubles.

The station has from the beginning made a policy of supplying material for research and for museum purposes to Russian institutions and others by special arrangement with the authorities in charge. It conducts no systematic programme of zoological or hydrographical exploration, though several interesting surveys of the vertical and bottom distribution of the fauna have been made by investigators at the station. The investigations carried on at the station have appeared in many journals, Russian and foreign, but since 1900 the first part of each volume of the "Travaux" of the Royal Society of Naturalists of St. Petersburg is given over to papers produced at the station. No special publication is issued by the station.

The station is located on Katherina Harbor opposite the town of Alexandrovsk, north of the city of Kola on the Kola fiord, about 12 miles from the open polar sea. The station is reached via Norway, Hammerfest, and the North Cape, by weekly steamer from Vardo, running from the end of March to the end of September; also from the beginning of June to the end of September by steamer (three days) from Archangel, which has connections by rail with St. Petersburg and Moscow.

The building stands on a barren granitic peninsula about 8 m. above sea level, facing the southeast. It is a plain but substantial wooden structure (11 by 16 m.) of two stories, of rectangular form, with central halls running part of the length of the long axis. Upon the ground floor the vestibule (2.2 by 4.5 m.) opens on the one hand to the aquarium room (4.5 by 5.5 m.) and on the other to the central hall (2 by 10 m.) leading to the dining room (4 by 6 m.). From this hall open a sorting room (4.5 by 4.5 m.) and five sleeping rooms (3.5 by 4.5 m.). From the dining room open the culinary department (4.5 by 5 m.) and another sleeping room (3 by 6 m.). Stairs ascend from the central hall to the floor above, upon which are located the two laboratory rooms (4.5 by 9 and 6.2 by 6.6 m., respectively) each abundantly lighted and with a row of four and five cubicals (2 by 2.5 m.) along the outer walls. Each cubical is formed by partial partitions not reaching the ceiling and is provided with a well equipped work table facing the window. A chemical laboratory (4 by 4.5 m.) and a comfortably furnished library and museum (4.5 by 6 m.) are upon the opposite side of the hall, where are also found two additional chambers (2.2 by 4.5) for the assistants. A storeroom (3 by 3 m.) and a dark room (1.5 by 3 m.) for photographic work are placed over the aquarium room in the projecting ell formed by that part of the building.

The building is heated throughout with huge Russian stoves. It is amply furnished with glassware, chemicals, and aquarium facilities and is piped for both salt and fresh water. The fresh water supply is furnished by hydraulic ram from a spring one-fourth km. from the station. The library contains a working collection of approximately 1,000 books and pamphlets, dealing mainly with the northern fauna and flora. A museum collection of the local fauna and flora is also in process of formation.

The pumping plant is housed in a small separate building. It consists of a Böttger hot-air engine attached to a vertical plunger-pump. The sea water is drawn through a 1½ inch lead sea pipe. On account of the extreme freshness of the surface waters in spring and early summer it is necessary to sink the intake to a depth of 15 m. to secure water of normal salinity. From the pump a main of 1½-inch lead pipe leads to an elevation of 9.3 m., where it discharges into two wooden tanks of 4 cu. m. capacity each. A distributing main of 1¼-inch lead carries the water thence to the sorting room, laboratories, and aquarium room. The laterals are of ¾-inch lead pipe, with hard rubber cocks.

The aquarium room is provided with a peripheral lead-topped table with sloping surface and marginal gutter. Rectangular glass accumulator jars, 50 to 60 in number, are used for aquaria on this table and their overflow runs on to the table and is carried away from the gutter in discharge pipes. The water is used but once. In the center of the room is a large aquarium tank 3 m. long, 1 m. wide, and 0.75 m. deep, so constructed that it may be divided by removable glass partitions into three smaller aquaria. Beneath this aquarium is a lead-lined basin with slat racks above for glass aquaria fed by siphons from the tank above. Overhead spray and surface outflow are used in the large aquarium. A natural aquarium with a capacity of 20 cu. m. is formed in the solid granite near the station, and the sea water from the laboratory is passed through this.

In addition to the laboratory the station has also a two-story dwelling used by the resident superintendent and the station servants, a two-story boathouse and tackle warehouse.

The field equipment of the station includes a 70-foot schooner with a 25-horsepower petrol motor for auxiliary power, a large sailboat (9 m. length, 2.7 m. beam) equipped with pump for plankton work, and a winch with 300 m. of wire cable for dredging, and another sailboat and three rowboats. There is an ample equipment of nets, dredges, seines, etc., for field work.

Kola fiord, upon which the station is situated, is 55 km. in length and 2 to 5 in width, with a mean depth of 25 to 50 m. and a maximum depth of 250 to 400 m. Some shoal water is found along shores and

near the few islands. Close by the station depths of 50 to 60 m. are found. The salinity of the water at surface levels is subject to great fluctuations. The shores are granitic and afford a firm substratum for attached forms of life. Full lists of the land flora and marine fauna are given in the paper of Derjugin (1906). In this list are recorded 32 species of Cœlenterates, 24 echinoderms, 98 mollusks, 19 tunicates, and 41 fishes, indicating a fauna of remarkable variety and richness, when the high latitude of the location is considered.

Literature: Dean (1894), Sand (1897), Faussek (1896), Derjugin (1906), Averinzev (1906, 1909).

RUSSIAN BUREAU FOR THE INTERNATIONAL INVESTIGATION OF THE SEA.

Ministry of agriculture and imperial domains.

Russian delegates: Prof. Dr. O. van Grimm, Dr. N. Knipowitsch, zoological museum, Academy of Sciences, St. Petersburg; Dr. L. Breitfuss, Zerkownaja 26, St. Petersburg.

The Murman expedition.

Director, Dr. L. Breitfuss.

Scientific assistants: Dr. A. Hausmann Dr. O. Hausmann, Dr. W. Issatschenko, Dr. A. Linko, Dr. A. Smirnow.

St. Petersburg office, Zerkownaja 27.

Field station and laboratory at Alexandrovsk, Gouv. Archangelsk.

The participation by Russia in the International Commission for the Investigation of the Sea is shared by two independent bureaus, the Finnish bureau with headquarters at Helsingfors, and the Murman coast expedition with headquarters at St. Petersburg, and field of operations on the extreme northwestern coast of the Empire from Varanger fiord on the Norwegian frontier to the margin of the White Sea. It shares with the Norwegian province of Finmark the climatic amelioration of the Gulf Stream and the resulting enrichment of its fauna and flora and fisheries, noted for centuries for their wealth.

The field of operations of the Russian bureau is a triangular area extending north from Kola fiord along meridian 33° 30′ to 75° north, thence to Goose Cape on Nova Zembla (72° north), and returning thence to Kola fiord. Explorations are also conducted in Barents Sea to 77° north, westward to Vardo, and eastward to the Kara Sea.

The Murman explorations were begun in 1898 under Doctor Knipowitsch and continued since 1902 under Dr. L. Breitfuss as a part of the international scheme. In addition to the scientific work along hydrographic, meteorological, geographical and biological lines carried out according to the programme of the International Commission in quarterly cruises, the Murman laboratory conducts an extensive work along industrial, educational, sociological and philanthropic lines with the object of developing these arctic fisheries and building up the race of native fishermen. The programme includes the mapping of fishing grounds, determination of the seasonal move-

ments of the fish, improvement in fishing tackle and vessels by introduction of new models, new methods of salting and curing, the use of ice, and the preservation of the salmon fisheries. Along sociological and philanthropical lines it includes the extension of the weather service and telegraph lines, establishment of life saving stations and ships, industrial agencies for purchase of supplies and marketing the product, the opening of orphanages, schools, and public baths, and medical inspection and relief.

The station also supplies from its abundant resources collections of animals and marine plants to schools and learned institutions, but does not seek to make provision in its shore laboratory for independent investigators.

In addition to the shore laboratory and coaling station at Alexandrovsk on Kola fiord, the equipment of the Murman station includes a specially constructed research ship, the *Andre Pervosvannyi*, a steel vessel of 336 registered gross tonnage, length 151 feet, draft 10 feet, carrying five officers and a crew of twenty-two men. The vessel has triple compound condensing engines of 420 horsepower, giving a speed of 10 miles per hour. It is fully equipped with steam winches for handling fishing gear and scientific instruments. The station also has the use, as need arises, of the administration steamer *Murman*, a wooden steamer *Phoca*, and several sailing vessels.

The equipment for biological work includes dredges, Sigsbee trawls, Hensen plankton nets, the Helgoland fry net, Petersen's young-fish trawl. The fisheries equipment is most ample, including long lines, set and drift nets, sack nets, fish and otter trawls. The hydrographic equipment contains Pettersson-Nansen water bottle, Negretti-Zambra and Nansen thermometers, several types of sounding machines, Ekman current meter and Secchi disks. The ship also carries a full equipment of meteorological instruments including a Pulfrich apparatus for measuring refraction and kites with meteorographs.

The results of the work of this expedition have been published in the international bulletin at Copenhagen and in Russia in a series of "Annual Reports," "Results of Expeditions," and special circulars of information as well as in widely scattered scientific contributions.

Literature: Breitfuss (1906).

PROFESSOR BORODIN'S FRESH-WATER BIOLOGICAL STATION OF THE IMPERIAL SOCIETY OF NATURALISTS OF ST. PETERSBURG, LAKE SELIGER.

Director, Academician Ivan P. Borodin, botanical museum, Imperial Academy of Sciences, St. Petersburg, Russia.

Superintendent, Doctor Molcanov.

Founded in 1906 solely at the private expense of the director and of Professor Woronin of the Academy of Sciences and since maintained entirely by Professor Borodin. A gift of 5,000 rubles to the Imperial Society of Naturalists serves also as endowment.

The station was located from 1897–1905 on the eastern shore of Lake Bologoje between St. Petersburg and Moscow in a cottage of six rooms two of which provided laboratory places for six workers. In 1906 the laboratory was transferred to Lake Seliger, 80 km. in length and the source of the Volga. The station is on the western shores of the lake about 8 versts northwest of the city of Ostashkov, twelve hours by rail southeast of St. Petersburg. The superintendent is elected each year by the Society of Naturalists. The only charge made at the station is for board. Laboratory facilities and lodging are furnished to the workers. The laboratory is supplied with microscopes, microtome, paraffin bath, chemicals and glassware for biological work and through the cooperation of friends a very fair working library (see lists in "Berichte") of papers pertaining to the botany and zoology of fresh waters. There is also a field equipment and laboratory apparatus for quantitative and statistical plankton work.

The station is open in summer from May to September and is used solely for investigation by members of the Society of Naturalists. The results of the investigations, chiefly faunistic, systematic, and œcological appear in a series of "Reports of the Fresh Water Biological Station of the Imperial Academy of Sciences," two volumes of which have thus far been issued.

Literature: Borodin (1901, 1906).

RUSSIAN FISH-CULTURAL LABORATORY AT NIKOLSKOJE, GOUV. NOVGOROD.

Director, Dr. Oscar Grimm, Russian bureau of fisheries, St. Petersburg.
Superintendent, Dr. A. A. Lebidenzeff, Nikolskoje.

This laboratory is primarily a fish-cultural establishment, but connected therewith is a biological station. The main line of investigation in progress therein is the chemical examination of waters with reference to their relations to the problems of fish culture.

THE VOLGA BIOLOGICAL STATION.

Director, Dr. W. Meissner, Saratoff, Gouv. Saratoff.
Secretary of Saratoff Society of Naturalists, Mr. B. I. Dixon.

This station upon the greatest of the Russian rivers was founded in 1900 by a group of biologists in the Saratoff Society of Naturalists. The Saratoff station has been most fortunate in having as its directors in succession several of the foremost investigators in limnology in Russia. The first director Dr. W. Zykoff, fresh from his doctorate at the University of Moscow built up the station during the two years 1900–1902 of his connection. He was followed in 1903 by Dr. A. S. Skorikow and later in 1905 by Dr. W. Meissner who continued as director till 1909.

The station receives in addition to the local funds an annual stipend of 1,500 rubles from the Kultus Ministerium, and in 1903 received

by gift a 30-foot steel steam cutter for its field work. Its building provides places for seven or eight investigators. Applications for admission should be sent to the director or to the secretary of the society.

The lines of investigation followed at Saratoff have been mainly faunistic, with special reference to the invertebrates other than insects and to fishes. Special attention has been paid to the parasites of fishes, to the culture of the sturgeon, and to the plankton of the Volga.

The station is located in rented quarters near the bank of the Volga in the city of Saratoff. It is a plain one-story building (extreme dimensions 9 by 33 m.) containing a large laboratory (9 by 10 m.), library and aquarium room (7 by 9 m.), a dark room (2.5 by 2.5 m.), a collection room (2.5 by 8 m.) and a director's office (2.5 by 4 m.). The station is very fully equipped with movable aquaria, glassware, reagents, etc., for morphological work, has 3 microscopes of Hartnack, Verick, and Leitz, microtomes, and paraffin oven. There is a good working library of the current literature of fresh-water fauna and flora, and a good beginning has been made on a type collection of the local fauna.

The field equipment consists of a 30-foot steel steam cutter, *Naturalist*, a sailboat, *Daphnia*, and smaller boats for local expeditions. There is a full equipment of special trawls and dredges, Apstein nets, centrifuge and Zwickert counting microscope for plankton work.

The explorations at Saratoff have brought to light a wonderfully rich and interesting fauna and flora. Over 1,000 species have been found in the stream. Among them are no less than seven species of marine Crustacea from the Caspian area which have found their way not only into fresh water but to a distance of 900 versts from their normal habitat.

The Saratoff station is thus in a unique location in a rich field on one of the largest rivers of Europe, in a position of vantage to render signal service to the science of hydrobiology and fish-culture.

The publications of the station are issued as a series of "Raboty" (vol. 3 in 1909) included in the "Trudy" of the Saratoff Society of Naturalists.

Literature: Sovyet (1902), Skorikow (1903, 1903a), Meissner (1906, 1907, 1908).

HYDROGRAPHICAL STATION OF LAKE GLUBOKOJE, NEAR MOSCOW, RUSSIA.

Director, Prof. Dr. N. Zograf, professor of zoology, University of Moscow.
Superintendent, Mr. N. Voronoff, zoological laboratory, University of Moscow.

This, the oldest fresh-water station in Russia, was opened as a movable summer station by Professor Zograf in 1888, which, in 1890, was permanently located on Lake Glubokoje (Lac Profond) in the

district of Rouza, near Moscow. This is an isolated lake, attaining a maximum depth of 30 m. It is free from contamination by factories or villages and presents a great variety of shore line. The station was lodged at first in temporary quarters, but in 1894 a small building specially for the station's accomodation was erected by Prince Dolgorodikoff. From 1894 to 1898 the station was administered by Dr. S. Zernoff. The building was enlarged and its work diversified along practical lines, but it was open only during summer months. In 1904 the slender budget of the station (400 rubles) from the section of ichthyology of the Acclimatization Society of Moscow was increased by a subvention from the ministry of agriculture and domains of 4,000 rubles and an annual stipend of 1,400 rubles. This made possible the equipment of the station with suitable apparatus and instruments for hydrographical and bacteriological work, the improvement of the library, and the erection of an additional laboratory accommodating sixteen students. A permanent superintendent was appointed and a programme of continuous work instituted. An ichthyological laboratory was opened in Moscow in connection with the new aquarium of the Zoological Gardens, which was destroyed in the revolution of 1905, but has been rebuilt on larger lines and was completed at the close of 1909. With improved facilities the station not only provides regular courses of instruction in summer months for university students and facilities for research for advanced students and specialists, but has also undertaken a definite programme of coordinated research along physical, chemical, bacteriological, and biological lines.

The station has published two volumes of "Travaux" and others are in preparation.

Literature: Zograf (1897).

BULGARIA.

BULGARIAN ZOOLOGICAL STATION, VARNA, BULGARIA.

At the seaport of Varna on the western shore of the Black Sea there is in process of erection a magnificent building for a zoological station and aquarium, which is exceeded in cost and dimensions only by the station at Naples. It was begun in 1906 and approaches completion at the close of 1909. The total cost of the structure will be in the neighborhood of 500,000 francs. The enterprise owes its origin to Prince (now King) Ferdinand of Bulgaria, who for many years has followed with interest the station at Naples. Minister Ivan Schischmanof, of the department of education, and Prof. P. Stoianoff, of the University at Sophia, have been instrumental in furthering the enterprise.

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